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AGE INCIDENCE AND HERITABILITY OF CANCER EYE IN HEREFORD CATTLE [1, 2]

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CANCER eye (ocular squamous carcinoma) affects man and most domestic animals. In cattle, it is found in the major dairy and beef breeds. Its incidence is usually considered to be higher in the Hereford breed than in others, but factors other than breed differences *per se* may influence the interpretation of breed susceptibility. Some workers believe that cancer eye has an hereditary basis, because scattered observations make it appear to "run in families" within breeds. Experiments to clarify the inheritance of cancer eye may yield clues concerning cancer in man.

This analysis is concerned with the age incidence of bovine cancer eye and the possible inheritance of susceptibility to this disease.

Source of Data

The data were obtained from the grade and purebred Hereford herds at the New Mexico Agricultural Experiment Station, State College, N. M. Eyes of all animals were examined routinely by the same man in the spring and fall of each year. Any animal with an ocular lesion that appeared malignant, or with a lesion severe enough to warn of serious difficulty if kept for the next season, was removed from the herd at the first opportunity consistent with shipping dates and the animal's reproductive state. A cow with calf at foot or soon due to calve when cancer was first recognized was shipped when that calf was weaned.

Records of disposal complete enough for analysis were available for the period from 1934 to 1954. These included 630 animals retained in

[1] Journal Series No. 101, New Mexico Agricultural Experiment Station, State College, New Mexico.

[2] This study was supported in part by research grant G-1 from the American Cancer Society and grant C-1751 from the National Cancer Institute of the Public Health Service.

[3] Public Health Service research fellow of the National Cancer Institute at Oklahoma A&M College, Stillwater, Oklahoma, and Member, Cancer Eye Study Section, the University of Texas M. D. Anderson Hospital and Tumor Institute, Houston, Texas.

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the herd for at least one year from date of birth. Few animals were kept past 11 years of age. The number of animals removed at each age for all causes is shown in table 1.

The lesions occurred on the globe, nictitating membrane, and the lids. Lesions involving the lids and nictitating membrane were about equally frequent, while lesions on the globe constituted only a small fraction of all lesions. Pigmentation of the eyelids was not recorded in these data.

TABLE 1. AGE OF ANIMALS AND INCIDENCE OF CANCER EYE WHEN REMOVED FROM THE HERD

Disposal age	No. animals removed at each age		Percentage[a] age incidence	Cumulative number with cancer	Cumulative[b] percentage
	Total	Cancerous			
1	15	0	0.0	0	0.0
2	10	0	0.0	0	0.0
3	71	0	0.0	0	0.0
4	81	3	0.6	3	0.5
5	73	6	1.3	9	1.4
6	59	14	3.7	23	3.6
7	54	12	3.7	35	5.6
8	56	21	7.9	56	8.9
9	77	14	6.6	70	11.1
10	97	5	3.7	75	11.9
11	29	0	0.0	75	11.9
12	2	1	12.5	76	12.1
13	3	1	16.7	77	12.2
14	3	2	66.7	79	12.5

[a] Number of animals with cancer÷number of animals of same age or older.
[b] Cumulative number with cancer÷630, the total number of animals.

Age Incidence

Some knowledge of the age at which cancer eye usually develops is necessary to interpret confidently the evidence on inheritance of susceptibility to the disease. The evidence on age incidence in the present data came from records of age at disposal, as shown in table 1. The percentage of age incidence (the fourth column in table 1) was computed by dividing the number of animals with cancer eye at disposal by the total number of animals that were of the same age or older at disposal.

No animal that left the herd under four years of age had cancer eye. After four years, the incidence of cancer eye tended to increase with age, at least to about 8 or 9 years. The high figures at 12, 13, and 14 years may be of doubtful meaning because the number of animals at

these ages was so low. However, the continued increase in the cumulative percentage incidence (last column in table 1) may indicate that when animals are retained in the herd to older ages, the incidence of cancer eye is likely to increase.

To test the independence of age and the occurrence of cancer eye, the 630 animals in table 1 were divided into four age classes so that the total in each class was as nearly alike as possible (table 2). The resulting chi-square of 49.7 was unmistakably significant ($P<.001$), indicating that age and the occurrence of cancer eye are related more

TABLE 2. ASSOCIATION BETWEEN AGE AND OCCURRENCE OF CANCER EYE

Age class (years)	Total observations	Observed frequency		Expected frequency	
		Cancer	No cancer	Cancer	No cancer
1, 2, 3, 4	177	3	174	22.2	154.8
5, 6, 7	186	32	154	23.3	162.7
8, 9	133	35	98	16.7	116.3
10 and older	134	9	125	16.8	117.2

Chi square=49.7 with 3 d.f. ($P<.001$).

than can be explained by chance alone. Age must therefore be considered when interpreting the presence of cancer eye.

Loeb and Jobson (1900), Wernicke (1935), Guilbert *et al.* (1948), Woodward and Knapp (1950), Forehand and Koger (a 1951 study which included many of the same data in the present study), Chandrasekharan Nair and Sastry (1954), and others have all reported that cancer eye is primarily a disease of the aged bovine. From the data presented in table 1, it appears that cancer eye is most likely to develop after five years of age. Woodward and Knapp (1950) reported increases in incidence at 5 and 7 years of age among cattle leaving the herd for all reasons. These increases in incidence at certain ages, in data on disposal, may indicate actual increases in incidence of cancer eye with age or may be the automatic result of fewer disposals for other things at these ages. No way of distinguishing between these possibilities is seen at present. Additional data on age at which cancer eye occurs are needed to clarify this point.

Measure of Cancer Eye Susceptibility

The age at which ocular lesions occur varies from 4 to 14 years in the present data and is distributed nearly "normally." It is plausible

that those animals which develop cancer eye at younger ages are, on the average, inherently more susceptible than those which first develop it when they are very old, although much individual overlap in this may occur. Accordingly, the age when cancer eye was first observed was used to develop a score for cancer eye susceptibility.

The basic assumption is simply that a cow developing cancer at 4 years of age, for example, is probably more susceptible than one which develops it at 9. Likewise, if one cow leaves the herd at 4 and another

TABLE 3. CANCER EYE SUSCEPTIBILITY SCORES OBTAINED FROM DATA ON 630 ANIMALS

Age attained	Animals leaving the herd with lesions		Susceptibility score	
	Cumulative			
	Frequency	Percentage	Cancerous	Non-cancerous
1	79	100.0	25	2
2	79	100.0	25	2
3	79	100.0	25	2
4	79	100.0	23	2
5	76	96.2	19	2
6	70	88.6	16	2
7	56	70.9	14	2
8	44	55.7	12	2
9	23	29.1	9	1
10	9	11.4	7	1
11	4	5.1	6	1
12	4	5.1	6	0
13	3	3.8	5	0
14	2	2.5	3	0

at 9 without either of them having developed cancer, the cow leaving the herd at 9 should be scored as being more resistant than the one leaving it at 4, since among those that do leave the herd at 4, some probably would have developed cancer if they had remained in the herd until the age of 9.

The method for developing the score is given by Pearson (1924). By using a table of the normal curve, the mean abscissa value was obtained for each class interval of the cumulative percentages shown in table 3. Relative values were found by setting equal to 100 the distance along the abscissa from the mean of the one-year-old class to the mean of the 14-year-old class. For convenience, the final scores were coded to small whole numbers by keeping the intervals between them in approximately the same proportions.

The score for animals which had not developed cancer before disposal was found by averaging the scores of all animals above that age. Zero was used at first as a working score for animals which did not develop cancer. These averages were all small and, in general, declined slightly as the age at disposal increased. For convenience they were then rounded to the nearest whole numbers. This led to a score of 2 for those which left the herd before they were eight years old without developing cancer, 1 for those which were 9 to 11 years of age, and 0 for those which were 12 or older at disposal. A slightly higher average susceptibility score for those which were still young when they were removed seems justified. Some of them probably would have developed cancer if other causes had permitted them to remain in the herd longer, although there is, of course, no way of knowing which individuals fell in this category.

The scoring system shown in table 3 is somewhat arbitrary in the relative importance it assigns to differences in the age at which cancer developed and to the general difference between cancerous animals and those which left the herd without ever developing cancer. For example, the animals which first developed cancer at 14 years of age were scored only one point more susceptible than those which left the herd before they were 8 years old without developing cancer, while those which were discarded with cancer when they were four years old were scored 20 points more susceptible than those which developed cancer at 14 years. Perhaps all the cancerous animals should be scored still higher. Qualitatively, the differences are in the right direction, but they may attach too much or too little importance to differences in age at which the cancer develops. However, the scores seem at least roughly proportional to the economic importance of the age at which cancer develops. Information concerning how well the score actually serves as a measure of susceptibility is meager. However, it was found that the score of daughters of cancerous dams tended to decrease on an average of 0.35 unit with each increase of one year in the dam's own age at which she developed cancer. Further analyses with other data will be needed to learn the regression of the animal's own real susceptibility, or of its genic value for susceptibility, on the age at which it first manifests its own lesions. In short, the scoring system contains some arbitrariness (which further studies may diminish), but is believed to fit both the biological and economic facts better than would a simple classification of "cancerous" and "non-cancerous." We see nothing more plausible to use at the present stage of investigation.

Heritability of Cancer Eye Susceptibility

The data for the heritability study came from 415 of the 630 animals, and involved 209 dams and 31 sires. Estimates of heritability of cancer eye susceptibility, as measured by the scoring system developed from these data, were derived from the paternal half-sib correlation (h_p^2) and from the intra-sire regression of daughter on dam (h_{od}^2). The paternal half-sib correlation was derived from the variance component analysis shown in table 4. The computational procedure was that out-

TABLE 4. ANALYSIS OF VARIANCE OF SCORES FOR SUSCEPTIBILITY TO CANCER EYE

Source of variation	d.f.	Mean squares	Expectation of mean squares	Estimated variances
Between sires	30	31.779*	E+13.042 S	S= 0.9083
Within sires	384	19.933	E	E=19.9330
Total	414			S+E=20.8413

* $P<.05$.

lined by Snedecor (1946), and the interpretation of the variance components has been discussed by Lush (1948) and by Lerner (1950). The estimate of heritability derived from the intra-sire regression of daughter on dam has been dicussed by Lush (1940). The heritability estimates obtained were:

$$h_p^2=0.17 \text{ and } h_{od}^2=0.29.$$

The estimate, $h_{od}^2=0.29$, based on 384 degrees of freedom, has a 95% confidence interval of .07 to .51. Any environmental correlation contributing to the likeness of dam and daughter would have biased h_{od}^2 toward being somewhat high, i.e., daughters of better performing cows may have been allowed to remain in the herd to older ages than daughters of poorer performing cows, thereby increasing their likelihood of developing lesions before disposal. If there was such an environmental correlation, it was unintentional and probably small. If any communicable environmental agent, such as a virus for cancer eye, were transmitted from dam to daughter, the effects of that would also be included in h_{od}^2 (Lerner and Cruden, 1951).

The paternal half-sib estimate, $h_p^2=0.17$, has an approximate 95% confidence interval of 0.03 to 0.32. The estimates, h_p^2 and h_{od}^2, are almost wholly independent because one is based on a daughter-dam resemblance and the other on the paternal half-sib resemblance. The only

thing the two have in common is the use of the daughter's phenotypes. The h_p^2 estimate here would be a bit smaller than would apply to a random sample of the whole breed, since many of the 31 sires were genetically related to each other. On the other hand, h_p^2 here would have been larger if a time trend were involved in the data; i.e., if among the various sires a long period of time were involved during which the incidence of cancer eye changed or the identification of lesions varied. Such factors would contribute to the size of h_p^2, but not h_{od}^2. By dividing the period from 1934 to 1954 into four periods (1934–39, 1940–44, 1945–49, and 1950–54) and comparing the incidence of cancer eye among the disposal animals in each of these periods, it was found that the incidence was 3.5% for the first period, 4.5% for the second period, 16.1% for the third, and 17.3% for the fourth. The probability of finding such a trend by chance alone is less than one in a hundred. Consequently, h_p^2 could have been biased by the significant time trend, but to what extent this was cancelled by the effect of related sires is not known. Probably the latter effect was more pronounced since h_p^2 is smaller than h_{od}^2, although sampling errors could have caused the same thing. The significant time trend could have been due entirely to genetic factors. In view of the sampling errors, not to mention the other factors which may have affected h_p^2 and h_{od}^2, the two estimates, 0.17 and 0.29, agree reasonably well.

Further evidence on the heritability of cancer eye, without regard to age of occurrence, was obtained from the incidence of the disease among the daughters of cancerous and non-cancerous animals. Of the five offspring whose dams and sires were both affected, one had cancer eye. From 350 matings in which neither parent was affected, only 11% of the progeny showed cancer involvement. From 70 matings in which only the sire had cancer eye, the incidence among the progeny was 26%. Thus 2(26–11) yields 30% as an estimate of heritability based on a regression of offspring on sire. From 70 matings in which only the dam showed cancer involvement, the incidence among the progeny was 22%. Again, 2(22–11) yields 22% as an estimate of heritability based on a regression of offspring on dam. This is much the same as the estimate of 29% from the intra-sire regression of offspring's score on the dam's score, but is uncorrected for sire differences and could contain the effects from any time trends. The probability of securing by chance alone the observed incidences among progeny of cancerous and non-cancerous parents was less than one in a hundred. It thus appears that inheritance is an important factor in the occurrence of cancer eye,

with approximately 20 to 30% of the total variability due to additive effects of genes.

No other estimate of heritability has been reported for cancer eye susceptibility. However, using some of the data included in the present study, Knox (1949) found significant sire differences in incidence of cancer eye. Wernicke (1935), Woodward and Knapp (1950), and Forehand and Koger (1951) have also indicated that the disease is probably influenced by heredity.

Effects of Sex

No apparent sex difference in incidence of cancer eye was found. Of 40 males for which records were available, four developed cancer eye. The expected number, if the incidence was the same as among females, was five. Wernicke (1935) considered the disease to be more common in females than males, but this finding was intuitive, since 9 of the 12 diseased animals included in his pedigree were females and 3 were males. When the number of males expected to develop the disease from the incidence among females is computed in his data, a sex difference in incidence is not observed.

Summary

The age incidence of bovine cancer eye (ocular squamous carcinoma) and the inheritance of susceptibility were investigated. Records of disposal complete enough for analysis of age incidence in one herd were available for the 21-year period from 1934 to 1954 inclusive on 630 animals retained for at least one year. For inheritance studies, 415 of these animals from 209 dams and 31 sires were available.

Cancer did not occur in animals leaving the heard before they were four years old. After the age of four years, cancer occurrence increased with age significantly more than would be expected if age and occurrence were independent. No sex difference in incidence was apparent.

A score for cancer eye susceptibility was developed on the plausible assumption that the more susceptible animals tend to develop lesions at younger ages. An estimate of heritability of cancer eye susceptibility derived from the paternal half-sib correlation of these scores was 0.17. An estimate derived from the intra-sire regression of daughter's score on dam's score was 0.29. Other estimates based on regression of offspring on sire and dam, without scoring for age incidence, were 0.30 and 0.22, respectively. Possible biases in these estimates are discussed.

Further studies on age incidence, predisposing causes, and hereditary aspects of cancer eye in cattle are needed.

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OBSERVATIONS ON FERTILITY FOLLOWING INSEMINATIONS AT THREE STAGES OF THE SAME ESTRUS[1]

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NUMEROUS workers have demonstrated that fertility is highest when cows are inseminated late in heat or shortly after the end of heat (Kirillov, 1937; Hoelzer, 1949; Masuda *et al.*, 1950; Trimberger and Davis, 1943; Laing, 1948b). In a group of cows permitted unlimited matings, the conception rate was higher than in a similar group of cows limited to two matings at the beginning of estrus (Laing, 1945a). The difference in conception rate was attributed to a closer timing of insemination to ovulation.

In some investigations, inseminations have been timed to ovulation as ascertained by rectal palpations. Trimberger (1948) obtained the highest conception when cows were bred between 6 and 24 hours before ovulation. Low conception rates resulted when the elapse of time from ovulation to insemination was as short as 2 hours. Barrett (1948) inseminated heifers at various times after ovulation to ascertain the influence of time after ovulation on fertilizability of ova. There was a decrease in fertility with an increase in time of insemination after ovulation. His data suggest that over-age ova may be a cause of early embryonic death.

This study was undertaken to ascertain whether insemination at three stages of the same estrus would indicate a time of insemination with respect to stage of estrus and ovulation that was more favorable to conception than another. The findings reported in all of the papers reviewed were based on between-animal comparisons. The aim was to give a within-animal and within-estrus comparison.

Experimental Methods

Grade Holstein cows were used. They were considered ready for breeding 60 days after parturition unless abnormalities of the repro-

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[2] The authors are grateful to P. H. Phillips of the Dept. of Biochemistry for the use of the cattle for this study, to Wilmer G. Miller of the Dept. of Genetics for aid in performing the blood typing and analysis of results, and to Wisconsin Scientific Breeding Institute and Southern Wisconsin Breeders Cooperative for providing semen for Trials I and II and Trial III, respectively.

ductive tract indicated otherwise. Heat dates previous to the one in which they were experimentally inseminated were established on all cows. For three days prior to an anticipated heat date a cow was checked with an estrogenized ovariectomized heifer, a nymphomaniac cow, or another cow at 0600, 1400 and 2200 hours in Trials I and II, and at 0800, 1600, and 2400 hours in Trial III. A cow was considered to be in heat when she would stand for a teaser animal to mount. Heat was calculated as having begun 4 hours prior to the heat check when the cow was first observed in heat. The termination of estrus was ascertained by heat checks at 4-hour intervals, beginning 8 hours after the check when the cow was first observed in heat. Cows were rechecked for termination of heat 4 hours after the check when she no longer stood for mounting. Heat was calculated to have terminated 2 hours prior to the heat check which indicated that the cow was no longer in heat.

Each cow was artificially inseminated at the heat check when she was first observed in heat, and again 12 and 24 hours later. The semen used for each insemination was from different breeds of bulls (Holstein, Guernsey, Angus). Approximately 1 ml. of semen was deposited in the uterus at each insemination. The mean concentration of sperm per ml. in Trial I for the fertile inseminations was 13,574,000, and for the infertile 13,910,000. Concentration of the semen used in Trials II and III was not determined. The sequence in which the semen of the three breeds of bulls was used was rotated to provide an approximately equal number of inseminations of each possible sequence. The semen was obtained from 48 different bulls (21 Holsteins, 17 Guernseys and 10 Angus) from two artificial insemination studs. Field fertility data, 60–90 day non-returns to first service, were available from the same collections of semen as were used for each insemination in the trials. The semen used was from the bulls which were regularly scheduled for collection on the day the cow was in estrus, so no selection of bulls was possible by the authors. Although there was variation in fertility among bulls, the distribution relative to fertility was random.

The ovaries were examined at the time of the first insemination to determine the position and status of development of the follicle. The time of ovulation was determined by rectal palpation at 4-hour intervals, usually beginning at the heat check when the cow was considered out of heat. Sometimes palpation for ovulation began earlier if the follicle seemed to be maturing and likely to rupture before the end of heat. The time of ovulation was calculated to have occurred midway between the palpation when the follicle was still intact and the palpa-

tion when the follicle was no longer present. From an analysis [3] of the blood types of the calves and their dams and the different bulls used in the various trials, the sire of each calf was ascertained (Stormont and Cumley, 1943). Two calves were born unattended and either were dead or died shortly after birth. When this occurred and a blood sample could not be obtained for test, the color markings of the calf were used as evidence for which breed of bull sired the calf.

In Trials I and II the cows were inseminated during the periods from March to June, 1952 and 1953, and in Trial III from March to August, 1954.

Eleven cows were deleted from the three trials of the experiment after one or more service periods. (For this study the three inseminations in one estrus was considered as a service period.) One cow was excluded from the results because the time of ovulation was not recorded. Others were excluded for such reasons as acute mastitis, abortion, uterine infection, and failure to settle after several service periods.

Results and Discussion

A summary of the results is presented in tables 1 and 2. The fertile inseminations ranged from 34 hours before to 14 hours after ovulation. Twenty-one cows calved to the first, 16 to the second, and 13 to the third insemination. The mean interval from a fertile insemination to ovulation was, on the first insemination 24.7 hours, on the second 11.0 hours, and on the third 6.6 hours. One of the second and many of the third inseminations were made after ovulation had occurred. If a spermatozoa maturation period is required as suggested (Austin, 1951, 1952; Austin and Braden, 1954; Chang, 1951), then spermatozoa deposited after ovulation may not have an equal opportunity to fertilize an ovum as compared to spermatozoa that have been in the tract longer.

Edwards (1955) and Radnabazaron (1951) working with mice and cattle, respectively, claim there is selective fertilization when females are inseminated with the mixed semen of several breeds or strains. In this study there were 19 calves sired by Angus, 16 by Guernsey, and 15 by Holstein bulls. This distribution was random according to the chi-square test. The chi-square test indicated that the distribution of fertile inseminations among first, second and third inseminations was also random ($P>0.05$). Within the limits of this study and the procedure employed, the time of insemination with respect to ovulation was not

[3] A complete summary of the blood types and the analyses for parentage of the animals involved is available upon request.

TABLE 1. FERTILITY OF INSEMINATIONS IN RELATION TO TIME OF OVULATION

Number of times interval sequence occurred	Intervals from insemination to ovulation					
	First insemination		Second insemination		Third insemination	
	hr.	No. of fertile inseminations	hr.	No. of fertile inseminations	hr.	No. of fertile inseminations
1	42		30		18	1
5	34	2	22	1	10	2
7	30	3	18	1	6	3
12	26	5	14	5	2	2
16	22	8	10	5	−2	3
6	18	3	6	2	−6	1
2	14		2	2	−10	
1	10		−2		−14	1
Total 50		21		16		13
Mean interval between successful insemination and ovulation, hr.		24.7		11.0		6.6

important to conception. It should be pointed out here that a small difference which is real could exist, but statistical tests of these data would not indicate it to be significant because of the small number of animals used.

The mean 60–90 day non-return rate, which was established by routine use of semen from the same collection in the field, was 72.6% for all bulls used for fertile inseminations, and 69.7% for those used for the infertile inseminations. The Angus bulls ranked highest in non-returns, Holsteins second, and Guernseys third.

TABLE 2. SUMMARY OF THE RELATION OF SEQUENCE OF INSEMINATIONS TO THE BREED WHICH SIRED THE CALF

Sequence of inseminations			Number sequence times occurred	Breed of sire of calf		
first	second	third		Holstein	Angus	Guernsey
Holstein	Angus	Guernsey	8	3	3	2
Holstein	Guernsey	Angus	7	2	1	4
Guernsey	Holstein	Angus	8	1	3	4
Guernsey	Angus	Holstein	9	3	3	3
Angus	Guernsey	Holstein	9	3	4	2
Angus	Holstein	Guernsey	9	3	5	1
Total			50	15	19	16

The mean age of the semen at the time of insemination was 16.3 hours for the fertile inseminations and 17.8 hours for the infertile inseminations. The range in age of semen at time of insemination was from 3 to 48 hours.

Although Andreev (1937) reported an improved non-return rate in artificial insemination centers that reinseminated the cows 10–18 hours after the first insemination, the three inseminations during an estrus period did not result in an exceptionally high conception rate. Of the cows that remained in the experiment, 50 conceptions resulted from 72 service periods for an average of 1.44 per conception.

The individual tendency to conceive at a particular interval before or after ovulation was determined for 17 cows that were in two or more trials. This figure was low ($r=0.20$) and not statistically significant. Seven follicles were accidentally ruptured during palpations after the cows had gone out of estrus. One of these five cows conceived in that service period.

Hart and Moody (1949) report that time of insemination in relation to ovulation affects the sex ratio in rats. In this experiment 29 (58%) of the 50 calves born were males. Thirteen of the calves (62%) were males from the first, ten (62%) from the second, and six (46%) from the third insemination. These percentages do not indicate any significant effect of time of insemination on the sex ratio.

The mean duration of estrus was 17.1 hours and the mean time from end of estrus to ovulation was 11.1 hours. The time of day when the majority of cows were first observed in estrus varied considerably among trials. Onset of estrus was observed as follows: Trial I—0600, 5 cows, 1400, 11 cows, 2200, 1 cow; Trial II—0600, 7 cows, 1400, 3 cows, 2200, 7 cows; Trial III—0800, 8 cows, 1600, 8 cows, 2400, no cows. The variations in the time of onset of heat do not appear to be the result of differences in the method of observation, for the mean duration of estrus and the mean time from end of estrus to ovulation were nearly the same for the three trials.

Summary

Cows were checked for beginning of estrus three times daily at 8-hour intervals and for termination of estrus at 4-hour intervals. Time of ovulation was determined by rectal palpations at 4-hour intervals. The mean duration of estrus was 17.1 hours and the mean period from end of estrus to ovulation was 11.1 hours. The cows were artificially insemi-

nated at the check when first observed in heat and again 12 and 24 hours later. Each of the inseminations was made with semen from a bull of a different breed. The order in which the semen from the different breeds was used was rotated. Paternity of the calves was determined by blood typing. Calves resulted from inseminations 34 hours before to 14 hours after ovulation. The mean interval from a fertile insemination to ovulation was 24.7 hours for the first, 11.0 hours for the second, and 6.6 hours for the third. Twenty-one cows calved from the first, 16 from the second, and 13 from the third insemination. Angus bulls sired 19, Guernseys 16, and Holsteins 15 of the 50 calves. The distribution of calves by inseminations and breeds was random. There was no indication that time of insemination had any effect on sex ratio. Three inseminations during the same estrus did not result in an exceptionally high conception rate.

Within the time limits of this study and the procedure employed, the time of insemination with respect to time of ovulation was not important to conception.

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AGE AT PUBERTY OF GILTS PRODUCED BY DIFFERENT SYSTEMS OF MATING [1]

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MANY of the pigs produced each year are farrowed by gilts. Gilts must be bred at approximately 8 months of age if they are to farrow as yearlings. Therefore the attainment of puberty by that age becomes an important factor in swine production. Previous studies have indicated that most gilts reach first heat between 6 and 8 months of age and that differences exist between inbred lines as well as between inbreds and line crosses, (Phillips and Zeller, 1943; Robertson *et al.*, 1951a, 1951b; Warnick *et al.*, 1951; Burger, 1952; Squiers *et al.*, 1952; Self *et al.*, 1955). Gilts reaching puberty at earlier ages will have experienced more heat periods by breeding age and might be expected to farrow larger first litters because of higher ovulation rates (Warnick *et al.*, 1951; Robertson *et al.*, 1951a, 1951b; Self *et al.*, 1955).

The present studies were made in an attempt to understand further the part that heredity plays in determining the age at puberty in gilts.

Materials and Methods

Data presented in this paper were collected during four years (1950, 1951, 1952 and 1954). Animals used were from the swine herd maintained by the Wisconsin Agricultural Experiment Station in cooperation with the U.S.D.A. Regional Swine Breeding Laboratory. The animals studied each year represented the different matings that were made available by the current swine breeding investigations.

Feeding and management plans were similar all four years. The gilts were farrowed during the period from February 15 to May 1. Pasture was provided as soon as possible in the spring, usually early in May, and was continued as long as it was available in the fall (usually early

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November), the gilts then being moved to dry lot. The litters containing the gilts were creep-fed until weaning at eight weeks of age and were continued on balanced concentrate supplement while on pasture. When in dry lot the gilts received the same ration [4] as they received on pasture with the exception that alfalfa meal was fed instead of ground wheat.

Data were collected on weight at 154 days of age and age at first heat. The gilts were checked daily for heat with vasectomized boars beginning at 154 days of age and continuing until circumstances in January or February (weather, housing, help) made it impractical to continue checking.

All animals not showing heat at the end of the observation period were slaughtered and those showing abnormalities of the genital tract were eliminated from the puberty study. To facilitate analysis those gilts which had failed to show estrus on the day of their last heat check were considered as coming in heat at that time. There were 5 of these animals in 1950, youngest age 250 days; 9 in 1951, youngest age 250 days; 11 in 1952, youngest age 300 days; and 11 in 1954, youngest age 300 days. Some of the variability was thus lost from the study due to the termination of heat checking before some animals had reached their age of puberty. If the checks had been continued this would have resulted in adding to the age of those groups already showing heat at a significantly greater age than the other groups to which they were compared in 1950, 1951, 1954. The animals not showing heat before the end of the heat checks were quite evenly distributed among the different systems of mating in 1952.

In 1950 and 1954 all gilts in each litter were used in the study while in 1951 and 1952 each litter was represented in the study by two gilts picked at random (one litter in 1952 was represented by only 1 gilt).

In 1950, 150 gilts from six inbred lines (four inbred Chester White—designated AK, PM, MA, B; one inbred Yorkshire—Y; and one line originating from a Chester White-Yorkshire cross—CY) and from many of the possible crosses of these inbred lines (two-line cross—2LX) were available for study. The average inbreeding of the dams of inbreds and line crosses was about 30% and of the inbred gilts about 40%.

Studies were made in 1951 of 106 gilts involving all of the inbred lines studied in 1950 when used in inbred and line-cross matings. The inbreds resulted from the matings of two-line-cross males with two-line-

[4] Dry lot ration composed of ground corn, 980 parts; ground oats, 710 parts; ground wheat, 150 parts; soybean meal, 140 parts; meat scraps, 60 parts; limestone, 20 parts; mineralized salt, 10 parts; and antibiotic-containing supplement, 5 parts.

cross females of the same cross ($2LX^2$). The average inbreeding of these litters was approximately 25%. The line crosses involved (1) matings between two different inbred lines (2LX)—dams inbred about 30%; (2) matings of inbred boars with unrelated two-line-cross sows (3LX); and (3) the matings of two-line-cross males to unrelated two-line-cross females (4LX).

In 1952, studies were made of 95 gilts from matings involving four of the original inbred lines (AK, PM, Y, CY) as well as outbred individuals of three different pure breeds (Duroc, Chester White and Poland China). The systems of mating available for study this year were (1) inbred sires on two-line-cross dams of unrelated lines (3LX); (2) two-line-cross sires on unrelated two-line-cross dams (4LX); (3) inbred sires on outbred dams of the same breed (topcross, inbred male—(TX_F); (4) inbred sires on outbred dams of different breeds (topcross-bred, inbred male—(TXB_F); (5) 2LX sires on outbred dams of the same breed (TX_{LX}); (6) 2LX sires on outbred dams of different breeds (TXB_{LX}); (7) outbred sires on 2LX dams (O-LX); (8) outbred sires on outbred dams of the same breed (PB); and (9) outbred sires on outbred dams of different breeds (XB).

The work in 1954 included 162 outbred gilts from the Poland China, Duroc, and Yorkshire breeds, as well as from all possible crosses between these breeds. The dams of these gilts comprised about 16 females taken at random (restricted as to health, weight and age) from each of three herds within each of the three breeds. Approximately four boars (each from a different herd and from herds other than those out of which the females were taken) were used to represent each breed in matings with these females.

The assumption made throughout this study was that systems of mating was a "fixed" variate, that line of dam, line of sire, litter, and gilts were "random" variates.

Results

The mean age at puberty for the inbreds over all lines in 1950 (table 1) was 227.7 days as compared to 193.4 days for the line crosses; a difference which was highly significant (table 2). No significant difference was found between dam lines nor was there any evidence that the effect of system of mating varied from one dam line to another (no significant interaction between dam line and system of mating).

TABLE 1. MEAN AGE AT PUBERTY BY LINE OF DAM AND SYSTEM OF MATING, 1950

Dam line	System of mating	No. gilts	No. litters	Av. age at puberty
	Inbred	6	2	232.0
MA	Linecross	16	5	196.9
	(Total)	22	7	206.5
	Inbred	9	4	206.2
PM	Linecross	13	3	199.1
	(Total)	22	7	202.0
	Inbred	7	3	218.6
AK	Linecross	10	4	184.1
	(Total)	17	7	198.3
	Inbred	7	3	243.6
B	Linecross	22	6	196.2
	(Total)	29	9	207.6
	Inbred	13	5	227.6
Y	Linecross	7	2	184.4
	(Total)	20	7	212.5
	Inbred	8	3	242.8
CY	Linecross	32	8	192.5
	(Total)	40	11	202.6
	Inbred	50	20	227.7
(Total)	Linecross	100	28	193.5
	(Total)	150	48	204.9

The mean ages at puberty for the four systems of mating studied in 1951 are given in table 3. The analysis of variance (table 4) showed a highly significant difference between them. By application of the multiple range test (Duncan, 1955), the difference between the inbred system of mating and the line-cross systems as a group was the only one found to be significant (table 3). Inbred offspring from line-cross dams ($2LX^2$) came in heat significantly later than line-cross offspring

TABLE 2. ANALYSIS OF VARIANCE IN AGE AT PUBERTY, 1950 [a]

Source	d.f.	M.S.	Error term
(a) System of mating (S.M.)	1	14361**	c
(b) Dam line (D.L.)	5	469	d
(c) S.M. × D.L.	5	441	d
(d) Litters/D.L./S.M.	36	1285**	e
(e) Gilts/litters	102	280	

[a] Because of disproportion in number of gilts in the different dam-lines and S.M., the method of analysis for R × 2 tables given by Snedecor (1946, 1953) was used.
** $P<0.01$.

TABLE 3. MEAN AGE AT PUBERTY BY SYSTEM OF MATING, AND DIFFERENCES BETWEEN THEM AS SHOWN BY THE MULTIPLE RANGE TEST, 1951 [a]

System of mating [b]	3LX	4LX	2LX	$2LX^2$
No. of litters [c]	14	18	10	11
Average age at puberty	198.4	208.2	214.5	244.0

[a] Means contained in the same underlined subset do not differ at the 5% level of probability.
[b] See material and methods for definition of symbols.
[c] Each litter is represented by two gilts, in each system of mating.

from line-cross dams (3LX and 4LX) giving evidence of the effects of inbreeding of the individual on age at puberty. Further, inbred offspring from line-cross dams ($2LX^2$) reached puberty at a significantly later age than the line-cross offspring from inbred dams (2LX) (which did not differ significantly from 3LX and 4LX), indicating that inbreeding of the individual is of greater importance than the inbreeding of the dam in influencing age at puberty.

Effects of System of Mating and 154-Day Weights on Age at Puberty

Previous work concerning age at puberty (Warnick *et al.*, 1951; Robertson *et al.*, 1951a; Self *et al.*, 1955) has indicated that there is a negative association between 154-day weight and age at puberty for individual gilts of the same breeding when fed and housed together. In the present study significant negative correlations were observed, on the average −0.38, within the inbred groups of the different lines in 1950, and −0.34 within the different systems of mating in 1951. The average correlation, +0.08, within the different line-cross groups of 1950, was not significant.

The highly significant difference in age at puberty between the inbred and line-cross gilts, and the commonly observed depressing effect of inbreeding on growth rate, raises the question whether there was a difference in the age at puberty of the two kinds of gilts when considered in the same 154-day weight classes. This largely removes effects of

TABLE 4. ANALYSIS OF VARIANCE IN AGE AT PUBERTY, 1951

Source	d.f.	M.S.	Error term
(a) System of mating	3	9263**	b
(b) Litters/S.M.	49	1033*	c
(c) Gilts/litters	53	575	

* $P<0.05$.
** $P<0.01$.

TABLE 5. MEAN AGE AT PUBERTY BY SYSTEM OF MATING AND 154-DAY WEIGHT CLASSES

	1950				1951			
	Inbreds		Line crosses		Inbreds		Line crosses	
154-day wt. classes	No. gilts	Av. age at puberty	No. gilts	Av. age at puberty	No. gilts	Av. age at puberty	No. gilts	Av. age at puberty
<100	18	234.4	6	195.0	4	259.0	3	255.0
100–119	15	223.5	12	185.9	6	253.3	16	223.3
120–139	8	229.5	17	196.7	8	235.2	23	198.5
>139	9	219.7	65	193.9	4	232.5	42	200.9

growth rate up to 154 days of age. An arbitrary classification of weights was made independent of age at puberty (table 5).

The analyses of variance (table 6) indicate a highly significant difference in age at puberty between systems of mating after the gilts had been classified on the basis of 154-day weights. In fact, in neither year was there a significant variation in the effect of inbreeding on age at puberty traceable to 154-day weights (non-significant interaction of system of mating and weights).

It appears that the retarding effect of inbreeding on age at puberty involves factors additional to its retarding effect on growth to 154 days of age.

Comparison of Ages at Puberty in Topcrosses, Line Crosses, and Conventional Purebreds and Crossbreds

The systems of mating available for the study in 1952 allowed further study of the effects of line crossing as well as preliminary studies of the effects of conventional purebreeding and crossbreeding on age at puberty.

TABLE 6. ANALYSIS OF VARIANCE IN AGE AT PUBERTY AND 154-DAY WEIGHT CLASSES [a]

	1950			1951		
Source	d.f.	M.S.	Error term	df.	M.S.	Error term
(a) System of mating	1	26790**	c	1	14161**	c
(b) Weights	3	532		3	4131	
(c) S.M. × wts.	3	545	d	3	478	d
(d) Gilts/S.M. × wts.	142	584		98	688	

[a] Because of disproportion in number of gilts in the different weight classes and systems of mating, the method of analysis for R × 2 tables given by Snedecor (1946, 1953) was used.
** $P<0.01$.

TABLE 7. MEAN AGE AT PUBERTY BY SYSTEM OF MATING AND DIFFERENCES BETWEEN THEM AS SHOWN BY THE MULTIPLE RANGE TEST, 1952 [a]

System of mating [b]	XB	TXB_{LX}	O-LX	4LX	TXB_F	TX_{LX}	3LX	PB	TX_F
Number litters [c]	7	7	7	5	5	4	4	7	2
Av. age at puberty	221.7	224.6	231.4	239.0	245.4	257.6	258.6	285.1	297.2

[a] Means contained in the same underlined subset do not differ at the 5% level of probability.
[b] See materials and methods for definition of symbols.
[c] Each litter is represented by two gilts, in each system of mating, except 4LX where one litter was represented by one gilt.

The mean age at puberty for each system of mating is indicated in table 7. The analysis of variance (table 8) showed a difference which approached significance ($p \cong .08$). A further analysis was made with the multiple range test using significant ranges applicable for the 5% level of probability. The results of this analysis are shown in table 7. A significant difference was shown only between the conventional crossbreds (XB) and the conventional purebreds (PB) and topcross purebreds (TX_F). That all the purebred animals have a tendency to reach puberty at a later age than the crossbred animals, however, can be seen by noting that the different systems of mating involving purebreeding (PB, TX_F, 3LX, TX_{LX}) are located to the right in table 7 and those systems of mating which are crossbred or predominantly crossbred (XB, TXB_{LX}, O-LX, 4LX, TXB_F) are located to the left. The non-significant difference between 3LX and 4LX is in agreement with the 1951 results.

The older age at which the conventional purebreds (PB) reached puberty as compared to the conventional crossbreds (XB) suggest that non-additive inheritance is involved. However, the number of gilts was too small to justify analysis of the differences between the various crosses and the means of the respective parent breeds.

The purebred matings in 1954 were Poland China (PP), Duroc (DD), and Yorkshire (YY). The crossbred matings were Poland-Duroc

TABLE 8. ANALYSIS OF VARIANCE IN AGE AT PUBERTY, 1952

Source	d.f.	M.S.	Error term
(a) Systems of mating	8	6505*	b
(b) Litters/S.M.	39	3104	c
(c) Gilts/litters	47	2018	

* ($p \cong .08$).

TABLE 9. MEAN AGE AT PUBERTY BY MATING TYPES, AND DIFFERENCES BETWEEN THEM AS SHOWN BY THE MULTIPLE RANGE TEST, 1954 [a]

Mating types [b]	YP	PP	DY	DP	PY	PD	YD	DD	YY	Total or Average
No. gilts	13	13	19	28	19	25	13	17	15	162
No. litters	4	7	7	10	7	9	4	7	9	64
Av. age at puberty	194.8	200.4	204.3	208.8	208.9	210.5	231.8	241.9	267.1	217.5

[a] Means contained in the same underlined subset do not differ at the 5% level of probability.
[b] See materials and methods for definition of symbols.

(PD) and Duroc-Poland (DP), Poland-York (PY) and York-Poland (YP), Duroc-York (DY) and York-Duroc (YD). The first letter denotes breed of sire. The averages for the different mating types are shown in table 9.

Analysis of variance of the 1954 data found a highly significant difference between mating types (table 10). The multiple range test (table 9) showed that the Yorkshire breed differed significantly from the Poland and all the crosses. The Duroc did not differ from the Yorkshire or York-Duroc but differed from the Poland and the remaining crosses.

The study in 1954 furnished sufficient data to test the question that arose in the 1952 study, as to whether there is evidence of a non-additive type of inheritance.

The three differences in age at puberty (average of the means of the purebreds minus the average of the means of their reciprocal crosses) were summed (table 11). A value for "t" was calculated using a standard error derived from the mean square between litters within mating types.

A significant difference ($p \cong 0.03$) was found indicating that the inheritance of age at puberty in the breed crosses tended to be non-addi-

TABLE 10. ANALYSIS OF VARIANCE IN AGE AT PUBERTY, 1954

Source	d.f.	M.S.	Error term
(a) Mating types	8	8536**	b
(b) Litters/mating types	55	1921**	c
(c) Gilts/litters	98	584	

** $P<0.01$.

tive. The crossbreds came in heat about as young as or younger than the earlier maturing of their respective purebred parents.

Discussion

The significant differences of a little more than a month in age at puberty of the inbred and linecross gilts in 1950 and 1951 indicates that inbreeding has a retarding effect. The fact that there was a fairly consistent difference in age at puberty between these systems of mating for those gilts which reached approximately the same weights at 154 days indicates that the retarding effect of inbreeding involves factors other than those associated with general growth.

The only indications of possible maternal effects on age at puberty

TABLE 11. COMPARISON OF PUREBREDS WITH THEIR CROSSES, 1954

Breeds involved	Poland and Duroc	Poland and York	Duroc and York	Total
Difference[a] in age at puberty between purebreds and crossbreds	11.50	31.90	36.45	79.85
Standard error of total[b]				35.22
t value				2.267
Probability				0.03

[a] Unweighted mean of purebreds minus unweighted mean of crossbreds.
[b] Derived from the mean square between litters within mating types.

were found in the reciprocal matings between Yorkshire and Duroc in 1954. The differences between the different kinds of line crosses in 1951 and in 1952 failed to show an effect of inbreeding of the dam on age at puberty.

The effect of heterosis on age at puberty shown by the line crosses in 1950 and 1951 was further emphasized by the differences found between purebreds and crossbreds in 1952. More detailed tests in 1954, with Yorkshires, Durocs, and Poland Chinas, also indicated that nonadditive inheritance is involved. Further, the trend was for heterosis to be greater in those crosses between purebred parents assumed to be the most diverse in origin, i.e., in those crosses involving Yorkshire with either Poland China or Duroc. This agrees with the conclusions of Winters, *et al.* (1944), working with crosses of inbred swine, and Durham, *et al.* (1952), with topcross gilts sired by boars from inbred lines.

Summary

Observations were made during four years on the age at puberty in gilts in the swine breeding experimental herd maintained by the Wisconsin Agricultural Experiment Station in cooperation with the Regional Swine Breeding Laboratory. The numbers of gilts used were, in 1950, 150; 1951, 106; 1952, 95; 1954, 162. The mean age at puberty of the inbred gilts in 1950 was 227.7 days. They were significantly older at puberty than the line-cross gilts (193.5 days).

The mean ages at puberty for the gilts representing the four systems of mating in 1951 (inbred, 244.0; two-line cross, 214.5; three-line cross, 198.4; four-line cross, 208.2) differed only in respect to inbreeding and line crossing, with no significant difference between the different line crosses.

Inbreeding of a gilt was shown to have a significant effect on the age at which she reached puberty. The effect of inbreeding of the dam was not shown to have a significant effect on the age at puberty of her offspring.

Significant differences were found between the inbred and line-cross gilts when classified into 154-day-weight classes to remove much of the effect of differences in growth rate.

The 1952 studies indicated a significant difference between purebreds and crossbreds. Differences between different line crosses were non-significant, as they were in 1951.

Differences in age at puberty in 1954 were found between mating types within the purebred and crossbred systems of mating as well as between the two systems.

Differences shown between the average age at puberty of the reciprocal crosses between two breeds and the average age at puberty of their purebred parents suggest non-additive inheritance.

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FURTHER STUDIES IN THE INDUCTION OF ESTRUS IN LACTATING SOWS WITH EQUINE GONADOTROPHIN

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IT has been reported previously that injection of 1000 I.U. of equine gonadotrophin into lactating sows between the 39th and 68th day of lactation produced estrus in 26 of 27 sows and pregnancy subsequent to breeding in a high percentage of cases (Cole and Hughes, 1946). Sows injected prior to the 39th day did not manifest heat regularly.

The present study was initiated to determine the effect of stage of lactation, number of matings, interval between injection and estrus, dosage of hormone, and size of litter at time of injection on the response of lactating sows to equine gonadotrophin injection.

Experimental

One hundred and one sows (Berkshire, Duroc, Hampshire, and Poland China) were injected intramuscularly with a single dose of 1120 to 3400 I.U. between the 20th and 50th day of lactation (the day of farrowing was designated as the first day of lactation). The gonadotrophin used, method of injection, and testing of sows for estrus were similar to those reported previously (Cole and Hughes, 1946). At the time of injection, sows varied in age from 1 to 5 years except for three that were 6, 7, 9 years, respectively. Weight [2] varied from 250 to 650 lb. Sows were managed in the herd under standard practices.

In addition to this experiment with sows in the University herd, a field trial was run in a purebred Berkshire herd in which injections were made by the farm manager according to our instructions. Testing for estrus and breeding was supervised by the herdsman.

Since Baker *et al.* (1953) reported that 76% of 29 non-suckling sows and sows suckling for only 2 days would come into heat from 8 to 16 days after farrowing, it was considered essential to determine the number of untreated sows in our herd coming into heat while suckling their litters. Accordingly, 10 sows were used as controls and checked for estrus daily with a boar from day-8 to day-56 of lactation.

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[2] Sows were not weighed at injection. Weights are estimates based on regular monthly weighings of the herd.

Results and Discussion

Of the 10 untreated sows checked daily for estrus from day-8 of lactation to weaning, none showed any symptoms of estrus during this period. The size of litters of these 10 sows on the 56th day of lactation varied from 4 to 7 with a mean of 5.90 ± 0.43.[3] It appears justified, therefore, to assume that the occurrence of estrus periods following the injection of the hormone were the results of the treatment.[4]

Seventy-six percent (34 of 45) of the sows injected between the 20th and 39th days, as compared to 86% (48 of 56) of those injected between the 40th and 50th days, came into estrus (table 1) within 14 days. The present study indicates that estrus can be induced as early as the 20th day in a good percentage of cases. It also indicates that the results to be anticipated when the injections are made following the 40th day of lactation may not be quite as spectacular as the former study (Cole and Hughes, 1940) indicated.

Only 44% of the sows (19 of 43 on which information was available) injected between the 20th and 39th day of lactation farrowed, whereas 66% (37 of 56) injected between the 40th and 50th days of lactation farrowed. As is indicated in table 1, however, most of the sows were bred only once on the first day of estrus. Treated sows not settling showed normal heat periods later in all cases, and all of these sows retained in the herd settled when serviced during these normal heat periods. The work of Lewis (1911) and McKenzie and Terrill (1935) would indicate that this is not the best time to breed. During three of the years that trials were run, some sows were mated a second time, 24 hours after the first breeding (table 2). It is evident that breeding a second time on the second day of estrus was effective in increasing conception rate. In six of the double matings, boars of two breeds were used, and 45 of 56 pigs farrowed were from the second mating. The majority of the pigs in each of 5 of the 6 litters came from the second mating. These results would be expected from the work of McKenzie (1932) and McKenzie and Miller (1930). In this study there was no evident influence on size of litter as a result of single vs. double matings, but the sample was small when breed differences were taken into account. The data in table 2 indicate that the percent conception would have been increased had all

[3] Standard error of the mean.

[4] Seven sows were checked for postpartum heat starting the day after farrowing by running them in a pen with a boar twice daily. All showed estrus with an average interval of 2.57 ± 0.30 days following farrowing which compares closely with intervals of 2.4 and 2.8 days reported by Warnick and associates (1950) and 2.25 days reported by Baker *et al.* (1953). Two of the sows were serviced but failed to settle.

TABLE 1. INDUCTION OF ESTRUS IN LACTATING SOWS IN UNIVERSITY HERD WITH EQUINE GONADOTROPHIN

(The data in columns 3, 4, and 5 are referred to in the same order as sow numbers are listed in column 1. Day of farrowing was designated as the first day of lactation.)

Sow no.	Day of lactation injected	Dosage, I.U.	Interval from injection to estrus, days[a]	Number of pigs born[b]
B104*[c], B310, H115, H201, P72,* P361	20	2600, 2600, 2600, 2600, 2600, 2600	5, x, x, 5, 4, 4	x, x, x, x, x,[d] 11
B172	21	2600	x	x
D207s	29	3000	5	14
B103, D318a, D318b, P70, P81g*	30	2600, 3000, 3400 2600, 2600	3, 6, 5, 4, 4	x, 8, 15, 12, 12
B154,* D24, D69, D138, D139, D183, D314, D333, D365,* H1s, H3, P34, P72, P109	31	2600, 3400, 3600, 2600, 2600, 2600, 3000, 3400, 2600, 2600, 2600, 2600, 2600, 2600	3, 5, x, x, x, 4, 7, 7, 5, 6, x, x, 6, 5	8, x, x, x, x, 14, 8, x,[e] x, 13, x, x, x, 6
B172, D105, D311, D365, H107, P116,* P162	32	2600, 2600, 2600, 3400, 2600, 2600, 3400	x, x, 4, 5, 5, 4, 5	x, x, 11, x, x, 7, 9
D6, H113, P64, P109 P116, P319, P362	33	2800, 2600, 3400, 3400, 3400, 3400, 2600	6, 4, 4, 5, 5, 4, 4	x,[f] x, x, 6, x, x, 18
P56	34	2600	x	x
B205*	38	1400	4	10
B103,* H320	39	1400, 1400	5, 5	x, 6
B205, D5g,* D105, D106, D145, D165, D304, D314, D342, H1s, H1sb, H211,* P7,* P361, P362	40	1500, 1400, 3400, 1500, 1500, 1500, 1500, 3400, 1500, 1500, 1400, 1500, 1400, 1400, 1500	x, 5, 5, 11, 4, 5, 4, 3, 5, 4, x, 5, 6, 3, x	x, 15, 13, x, 9, 12, 8, 11, x, x, x, 10, 8, x, x
B310,* B316, D22, D118,* D146, D183, D220, H1g, H4, H24, H114,* H211, P15,* P103, P112, P159, P318, P319,* P359,* P361*	41	1400, 1400, 3400, 1400, 1400, 3400, 1500, 1400, 1400, 1400, 1500, 1400, 1400, 1600, 1500, 1500, 1400, 1600, 1600, 1600	6, 6, 4, 5, 5, 3, 8, 7, 3, 6, 4, 5, 5, 3, 4, x, x, 3, 3, 3	x,[g] x,[g] 15, 6, 8, 14, 8, 6, 13, 6, x, 5, 2, x, 7, x, x, 11, 13, 9
D20, D53,* D106, D110,* D183, D207, D311, D333, P60, P81s, P103, P116, P160, P319	42	1500, 1400, 3400, 1600, 1500, 1400, 1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500	7, 3, 5, 5, 4, x, 4, x, 4, x, 4, 4, 5, 4	7, x, x, x, 7, x, 10, x, x, x, 10, 9, 5, 7
D113, D145, H210, P109	43	2500, 1400, 1400, 1500	3, 7, 3, 4	x,[h] 14, x, 11
D106, D111	48	1330, 1120	5, 14	3, 12
D246	50	1260	4	2

[a] A value in this column indicates estrus induced; and 'x' indicates failure.
[b] A value in this column indicates sow farrowed; and 'x' indicates failure.
[c] An asterisk (*) means the sow was serviced twice, second time 24 hr. after first.
[d] Sow died on 72nd day of gestation—autopsy proved pregnancy existed.
[e] Sow died on first day following service—pregnancy undetermined.
[f] Animal disposed of before pregnancy determined.
[g] Sold 76th day of gestation—sows appeared pregnant.
[h] Aborted 74th day of gestation.

the sows been mated again on the second day of estrus. The average gestation period for sows successfully treated in the University herd was 115.75 ± 0.23; and the Berkshire herd in the field study, 117.45 ± 0.41. Taking into account the gestation periods for untreated sows in the University herd of the same breeds and in the Berkshire herd in the field, these gestation periods do not differ significantly from those expected.

Following gonadotrophin injection, the sows which responded came into estrus in 3 to 14 days with a mean of 4.81±0.14 days. In only 3 of 82 instances in which sows expressed estrus was the interval from injection to estrus longer than 7 days. Sixty-five of 82 expressed estrus between the third and fifth day following injection.

TABLE 2. BREEDING ONCE ON FIRST DAY COMPARED TO BREEDING ON BOTH FIRST AND SECOND DAYS OF ESTRUS

Day of lactation	No. sows	No. sows farrowing	Percent sows farrowing
	One breeding[a]		
20–39	34	13	38.3
40–42	37	22	59.5
	Two breedings[b]		
20–39	9	6	66.7
40–42	12	9	75.0

[a] First day estrus.
[b] 24-hour interval between.

Some sows were used in the experiment more than once (table 1). There was no indication that hormone treatment during one season affected its efficacy in subsequent seasons. Included in this and the former study (Cole and Hughes, 1946) were 8 sows treated during 3 different farrowing seasons. Of these 8 sows, 7 showed estrus following injection the first season as compared to 8 and 7, respectively, for the second and third seasons. Six litters were produced in each case subsequent to breeding. A similar trend is found in sows farrowing in two and four different seasons.

The number of sows farrowing appeared to be unrelated to the length of interval between injection and estrus. Twenty-eight of 39 (72%) coming into heat between day-3 and day-4 inclusively farrowed while 28 of 41 (68%) coming into heat from day-5 to day-14 after injection farrowed.

The average size of litter following treatment was 8.65±0.36. This

TABLE 3. SOW RESPONSES TO VARYING AMOUNTS OF GONADOTROPHIN [a]

University Herd

Day of lactation	Dosage I.U.	No. sows	Showing estrus		Farrowing	
			No. sows	%	No. sows	%
20–39	750–1400	9[b]	5	55.6	3	37.5
	2600–3400	34[b]	23	67.6	12	36.4
40–50	750–1600	45[c]	37	82.2	25	59.5
	3400	5	5	100	4	80.0
51–68	750–1260	17	16	94.1	16	94.1

[a] Includes data of Cole and Hughes (1946).
[b] One sow disposed of before pregnancy determined.
[c] Three sows disposed of before pregnancy determined.

compares to an average litter size of 9.48 ± 0.36 in sows from our herd without treatment. This difference is without significance when differences in age and breed are considered.

Dosages employed in the present study varied from 1120 to 3400 I.U. per sow or about 2 to 14 I.U. per pound of body weight.[2] The results of the present study have been combined with those of the former study (Cole and Hughes, 1946), where lower dosages were utilized (table 3). Increasing the dose before day-40 did not appear to improve the results. Injections of 750 to 1600 I.U. after day-40 were apparently more effective than larger doses (2600 to 3400 I.U.) prior to day-40. Sows occasionally come into heat after the 40th day naturally. These sows coming into heat without treatment may be producing very little milk as the peak of milk production in the sow is between the third and fifth week of lactation (Hughes and Hart, 1935; Niwa *et al.*, 1951; Smith, 1952). More data are necessary, however, before any definite conclusions regarding dose and stage of lactation can be drawn.

TABLE 4. RELATIONSHIP OF LITTER SIZE OR NUMBER OF SUCKLING YOUNG AT INJECTION ON THE EFFICACY OF GONADOTROPHIN [a]

No. suckling young	No. sows	Showing estrus		Farrowing	
		No. sows	%	No. sows	%
2–5	36[b]	28	77.8	19	54.3
6–7	45[c]	34	75.6	22	51.2
8–10	33[c]	28	84.8	17	54.8

[a] Includes data from Cole and Hughes (1946).
[b] One sow disposed of before pregnancy determined.
[c] Two sows disposed of before pregnancy determined.

Cole and Hughes (1946) briefly reviewed information indicating that estrus inhibition in the rat may be due to lactogenic hormone. Meites and associates (1941) reported that size of litter in suckling rabbits had no relationship to the anterior pituitary content of lactogenic hormone. In this study the number of suckling young at time of injection had no apparent influence on the effect of gonadotrophin (table 4).

TABLE 5. INDUCTION OF ESTRUS IN LACTATING SOWS WITH EQUINE GONADOTROPHIN FIELD TRIAL

(The data in columns 3, 4, and 5 are referred to in the same order as sow numbers are listed in column 1. Day of farrowing was designated as the first day of lactation.)

Sow no.	Day of lactation	Dosage, I.U.	Interval from injection to estrus, days [a]	Number of pigs born [b]
40	35	840	x	x
42, 56	37	840, 840	x, x	x, x,
31, 44A	40	1500, 1500	x, x	x, x
4, 12, 20, 22, 26, 33, 40, 48, 51, 58a, 58b, 69, 78	41	840, 1500, 840, 840, 840, 840, 1500, 840, 1500, 840, 1500, 1500, 1500	4, 5, x, 4, x, x, 4, x, 4, x, 4, 6, 4	x, 3, x, 5, x, x, 10, x, 7, x, 15, 4, 4
24, 31, 41a, 44, 46, 47a, 47b, 48, 49a, 49b, 49c, 54, 55, 68, 78	42	1500, 840, 840, 840, 1500, 840, 1500, 1500, 840, 1500, 1500, 1500, 1500, 1500, 1500	4, x, x, 4, 4, x, x, x, x, x, 4, 4, 4, 5, 4	8, x, x, 3, 9, x, x, x, x, x, 4, 9, 8, 14, 10
7, 9, 25, 26, 28, 34, 35, 37, 66, 79	43	1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500	4, 3, 4, 4, 5, 3, 5, 4, x, 3	7, 10, 7, 10, 10, 8, 1, 4, x, 10
5a, 5b, 12, 27, 36Aa, 36Ab, 44B, 81, 85	44	840, 1500, 1500, 1500, 840, 1500, 1500, 1500, 1500	4, 4, x, 3, x, x, 3, 3, x	x, 13, x, 13, x, x, 9, 9, x
27, 28, 31, 34 40, 74, 77	45	1500, 840, 1500, 1500, 1500, 1500, 1500	x, x, 3, 4, 5, x, 4	x, x, x, 7, 9, x, 12
3, 6, 38, 41A, 47, 55, 77	46	1500, 1500, 1500, 1500, 1500, 1500, 1500	4, x, x, 5, 4, x, 3	x, x, x, 6, 7, x, x
1, 43, 44A	47	1500, 1500, 1500	x, x, 4	x, x, 11
37, 83	48	1500, 1500	4, 5	10, 4
5	50	1500	3	10
2, 16	52	1500, 1500	4, 4	8, 2
42	57	1500	2	10

[a] A value in this column indicates estrus induced; and 'x' indicates failure.
[b] A value in this column indicates sow farrowed; and 'x' indicates failure.

The results obtained in the field trial were not as satisfactory as in the University herd, but the increase in percentage of sows in estrus and farrowing as lactation progresses is evident (table 5). Sixteen of 33 sows (48.5%) injected between the 35th day and 42nd day of lactation came into estrus as compared to 23 of 36 (63.9%) between the 43rd and 47th days and 6 out of 6 (100%) between the 48th and 57th day. The interval between injection and estrus averaged 3.98 ± 0.13 days.

Similarly 15 of 33 (45.5%) of those injected between the 35th and 42nd day eventually farrowed compared to 19 out of 36 (52.8%) between the 43rd and 47th day and 6 out of 6 (100%) between the 48th and 57th day.

Upon interviewing the herdsman, it developed that he only tested sows with a boar when he anticipated that a sow was in estrus. Our operations in the University herd indicate that it is not possible to tell with any degree of accuracy when an injected sow is in heat without actually testing with a boar. Many sows with no external symptoms of estrus would stand and breed if turned with a boar for periods up to half an hour. In this field trial, the herdsman, unfortunately did not follow instructions.

Summary

Seven uninjected, lactating sows were observed for postpartum heat, and all evidenced estrus with an average interval of $2.57 \pm .30$ days following parturition. Ten uninjected lactating sows were tested daily for estrus from day-8 to day-56 of lactation without showing symptoms of estrus.

A single intramuscular injection of equine gonadotrophin was given to 101 lactating sows of 4 breeds. The injection induced estrus in 76% of the sows injected between the 20th and 39th days of lactation and in 86% of those injected between the 40th and 50th days. Following breeding at this time 44% farrowed when injected between day-20 and day-39 while 66% farrowed in the later injected group.

Results were not affected by number of suckling young at time of injection or length of interval from time of injection to estrus. Previous use of gonadotrophin did not appear to effect the efficacy in subsequent breeding seasons.

Breeding sows a second time, 24 hours after the first, resulted in a higher percentage of sows farrowing than breeding only once on the first day of estrus.

A field trial with 75 injections gave results somewhat less effective than those of the University herd. The reason for this difference is discussed.

The mean interval between injection and estrus was $4.81 \pm .14$ days in the University herd and $3.98 \pm .13$ days in the field trial.

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THE OCCURRENCE OF ESTRUS IN PREGNANT EWES

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SYMPTOMS of both physiological and psychological heat during pregnancy have been noted in several species, including rats (Nelson, 1929), mice (Crew and Mirskaia, 1930), hamsters (Krehbiel, 1952) and cattle (Donald, 1943). Rabbits, according to Hammond and Marshall (1925), frequently copulate during pergancy. Heats during pregnancy may be accompained by ovulations in mice (Rollhäuser, 1949) and in rats (Swezy and Evans, 1930). Women are also known to ovulate during pregnancy (Dubreuil and Riviere, 1950), Ovulations and the formation of accessory corpora lutea are the rule in mares (Amoroso, 1948) and elephants (Perry, 1953).

While the occurrence of heat during pregnancy has not been reported previously in sheep, two apparently authentic cases of superfetation have been recorded by Smith (1927) and Grant (1934), who found that a second conception had taken place one and two months respectively after the first fertile matings.

Material and Methods

In part of a study designed for another purpose, 103 Western ewes (Fine wool ewes × Down rams) were bred to three Down rams. Subsequently these ewes were checked for heat twice daily with several raddled vasectomized rams, until slaughter. Several of these ewes returned to heat after the initial exposure to fertile rams and were rebred in the belief that they had not conceived to the first service. Because the aim of this experiment was to study fertility of sheep and fertilizability of eggs, the ewes were checked for heat twice daily after the first mating and, if they returned to heat, they were rebred and slaughtered 3–4 days after the second breeding to check on ovulation and the fertilizability of eggs. At the time of slaughter, the number and size of the externally visible ovarian follicles were recorded, and the ovaries were preserved in Bouin's fixative for sectioning and examination.

Additional evidence was obtained on a flock of 50 ewes of predominantly Rambouillet breeding which were purchased in 1954 as

[1] Data from Ph.D. thesis of senior author.

virgin yearlings. They too were checked for heat daily with raddled vasectomized rams. It developed later that at least 24 of these ewes were pregnant at the time they were placed on experiment. None of these animals was killed and daily heat checks were continued for 115 days, during which 24 of the 50 ewes lambed. In some of the ewes which had lambed heat checks were continued post partum. In both the Western ewes and the Rambouillet ewes matings were frequently seen by two or more observers and the possibility that the ewes were marked accidentally by raddled rams is excluded in the majority of cases.

Results and Discussion

Of the 103 Western ewes, 50 were slaughtered at more than 20 days after breeding and thus had a chance to have at least one, and in some cases more than one, heat period after conception. Eleven of these ewes (22%) came into heat while pregnant. Eight had one heat, one had two heats, and two had three heats between conception and slaughter. These figures are not strictly indicative of the frequency with which heats occur during pregnancy because all these ewes were killed within 90 days after breeding.

Conception dates were not available for the Rambouillets but were calculated after lambing, assuming a gestation length of 150 days. The earliest heats were observed 40 days after calculated conception and no heat check occurred prior to that time. Fifteen of the 24 pregnant ewes (62%) in this group had heats during pregnancy. Intervals between heats were extremely variable in both groups, ranging from 3 to 40 days, with a mean value of 21.61 ± 2.11 days. There was no difference, in the interval between heats, between early and late pregnancy. This mean differs significantly from the mean cycle length of the non-pregnant ewes of the same flock, but does not differ from the cycle length of 23.1 ± 1.80 days observed in non-pregnant ewes which contained a foreign body in one of the uterine horns (Nalbandov *et al.*, 1955).

The data for early and late pregnancy show that heats are not confined to any part of the gestation period and may occur shortly before parturition (4 ewes mated 4, 5, 5 or 6 days before parturition).

There is some suggestion that the majority of heats were spaced at 17-day intervals or at multiples of this figure. However, an appreciable number of these intervals is outside the range of normal cycle lengths for sheep (Table 1).

It should be noted that the first estrus in the non-pregnant sheep of this flock occurred on August 14, that for pregnant ewes occurring August 27. No heat was recorded in either group after early February. This suggests that the occurrence of heats during pregnancy coincides with the normal breeding season of non-pregnant females, and that pregnancy heats do not occur during the non-breeding season.

The lambs of 24 ewes lambing in October were removed a few days after parturition, and all of the ewes came into heat within one to 61 days after parturition. The average interval from parturition to first

TABLE 1. ESTRUS IN PREGNANT SHEEP DURING EARLY AND LATE PREGNANCY

Heats during early pregnancy (Western ewes)		Heats during late pregnancy (Rambouillet ewes)	
Days from conception to first heat	Intervals between heats	Intervals between heats	Number of days from last heat to parturition
	days	days	
32	23, 33	20, 15, 30, 11	6
31	16, 30	33, 21, 31, 3	5
31	24	17, 15	40
		22, 22	27
		40	71
		9	31
		18	66
Single heats: 22, 19, 13, 18, 16, 13, 19, 23			Single heats: 26, 4, 16, 5, 36, 113, 70, 49
Average 21.5	25.2	20.5	
Average of all intervals	21.61±2.11 days		

post-partum heat was 23.9±3.18 days. No attempt was made to determine whether ovulations occurred at the first post-partum heat.

Some of the Western ewes were killed within four days after heat was observed on the assumption that they had failed to conceive. All of them were found to be pregnant, having conceived to a breeding occurring on the average 21.5 (+4 days) prior to autopsy (table 1, column 1). None of these had ovulated at the heat experienced during pregnancy. Histological sections of their ovaries showed no fresh ovulation points and no lutein tissue was found other than in the corpus luteum of pregnancy.

Ewes showing heat during pregnancy did not differ significantly in the number or size of follicles from ewes which did not show heat during pregnancy. For this reason data on ovarian morphology from all 75 ewes which were pregnant or had zygotes or fertilized eggs at the time of autopsy, were combined. There was a significant increase ($p=0.01$, Table 2) in the number of follicles of all sizes from about the 4th to the 30th day of pregnancy (actually this increase appeared complete by the 18th day of pregnancy). While the increase in follicle number during early pregnancy is most noticeable in follicles of the smaller sizes, it is not restricted to them. In fact, follicles in the larger sizes (7–10 mm.) are at least as numerous at 25 days of pregnancy as

TABLE 2. RELATIONSHIP BETWEEN STAGE IN PREGNANCY, FOLLICLE NUMBER AND FOLLICLE SIZE

Stage in pregnancy	Follicles per ewe	Follicle size (mm.)									Total
		2	3	4	5	6	7	8	9	10	
days	Average no.	5.3	2.5	1.7	1.6	1.3	1.1	1.0	1.0	0	15.5
3–8	% of total	43.4	24.2	9.8	9.0	8.2	4.1	0.4	0.8	0.0	
(29)[a]											
	Average no.	7.0	5.5	2.6	1.9	1.4	1.3	1.0	1.0	1.0	22.7
18–30	% of total	38.1	31.9	13.5	5.4	6.6	3.5	0.6	0.2	0.2	
(36)[a]											
	Average no.	10.0	4.4	2.6	2.3	0	2.0	0	0	0	21.3
45–115	% of total	69.4	15.3	9.0	4.9	0	1.4	0	0	0	
(10)[a]											

[a] No. of ewes.

they are at four days, suggesting that they have not degenerated or have been replaced by new enlarging follicles by the 25th day of gestation (table 2). Probably these follicles are maintained or grow under the influence of gonadotrophic hormone coming from the pituitary gland or from the placenta, though attempts to demonstrate gonadotrophic hormones in the blood and urine of pregnant ewes have thus far failed.

Follicle number achieved in early pregnancy is maintained throughout gestation, the decrease from 22.7 to 21.3 follicles being not significant (table 2). However, there is a highly significant ($p=0.01$) decrease in follicle size, so that by the 50th days of pregnancy 85% of the follicles are less than 3 mm. in diameter.

On the basis of this work it appears that heats without ovulation are not rare in pregnant sheep. It is probable that an appreciable number of ewes which come into heat while pregnant are culled as sterile. In

one such sample 50% of the ewes culled as sterile were found to be pregnant at autopsy. It is not known whether these ewes were culled because they continued to mate later than the majority of the flock.

Summary

About 22% of a band of 103 Western ewes was observed to mate one or more times during early pregnancy, pregnancy being verified at autopsy.

Fifteen of 24 pregnant Rambouillet ewes, all of which later lambed, mated during late stages of pregnancy, four of them mating four to six days before parturition.

The intervals between heats during pregnancy ranged from 4 to 113 days and averaged 21.3 days. These heats were observed during the normal breeding season of non-pregnant sheep and none occurred outside it.

Heats during pregnancy were not accompanied by ovulation in those ewes which were killed. This observation is restricted to the first one-third of gestation.

There was no difference in the number of lambs produced or the number of conceptions found between ewes which did and those which did not mate during pregnancy.

In ewes in which lambs were removed shortly after parturition, post-partum heats occurred 1 to 61 days after parturition averaging 23.9 days.

Ewes which continue to mate after exposure to fertile rams may be culled after conception because they are supposed barren.

There was a significant increase in follicle number and follicle size from early pregnancy (3–8 days after mating) to about the 25th day of gestation. During the remainder of pregnancy follicle number remained constant but follicle size decreased significantly.

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VARIATIONS IN THE LENGTH OF ESTRUS CYCLES AND THE BREEDING SEASON IN EWES

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THE duration of the ovine breeding season is a genetic characteristic which may vary from two or three estrus cycles per season in sheep of the Scotch Blackface breed (Marshall, 1922) to the almost continuous breeding seen in Merinos and Karakuls (Roux, 1936). The duration of the breeding season of crossbred sheep is intermediate between the durations of the two parent breeds (Hafez, 1952). Because of these observations, and because it is known that individual ewes may have breeding seasons which differ considerably in duration from the average of their breed, an experiment was performed to study the repeatability of such individual deviations from the average and, if possible, to determine the heritability of this trait.

In the course of this experiment, which involved daily heat checks of the same flock of sheep over a three-year period, the lengths of the estrus cycles were observed. Because these observations deviate considerably from generally accepted figures, they form part of this paper.

Materials and Methods

In April, 1951, 96 Western yearling ewes were purchased and daily heat checks with six raddled, vasectomized rams were begun. The parentage of the ewes was not known, but they appeared to be the result of crosses between fine-wool breeds and such breeds as Hampshire, Shropshire or Suffolks. Daily heat checks were obtained for the years 1951, 1952 and 1953 for all ewes, and also for 18 yearling Western ewes introduced into the experiment in the Spring of 1952. The latter group was added to provide a comparison between the performance of younger ewes with those which were one year older during two years of the experiment. The records of 14 ewes were eliminated because they died during the three-year period, leaving 100 records which were used in this study. The flock was fed and managed in such a way that all ewes were in uniformly good condition throughout the three years.

[1] Data from Ph.D. thesis of senior author.

Results and Discussion

The breeding season

The original flock showed a significantly earlier onset of the breeding season in 1951 (July 8) than it did in 1952 (August 27) or 1953 (September 1). The dates of onset of the breeding season in 1952 and 1953 did not differ significantly regardless of whether the ewes were one and two, or two and three years old when the comparison was made (table 1). Similarly, the breeding season in 1951 was significantly longer

TABLE 1. COMPARISON OF DATE OF ONSET AND THE DURATION OF THE BREEDING SEASON IN SHEEP

Age and number of ewes			Average date of start of breeding season		Duration of breeding season	
Age	No.	Year	Date	SD[a] (days)	Days	SD[a]
1	82	1951	July 8 (1)	40	228**	48
2	82	1952	Aug. 27 (2)	26	186	31
3	82	1953	Sept. 1 (2)	9		
1	18	1952	Sept. 4 (2)	10	174	18
2	18	1953	Sept. 4 (2)	13		

** Significantly different from others at 1% level of probability.
[a] SD—standard deviation.

($p=0.01$) than it was in subsequent years even though it ended significantly earlier ($p=0.05$) in 1951 (February 22) than it did in 1952 (March 1).

Further statistical analysis showed that there was no tendency for individual ewes in the original flock to be consistently early or late in the onsets of their individual breeding seasons or in the length of the breeding season in the three years. Such tendencies were not discovered even when comparisons were made between the first two years or the second two years separately, or between the first and third years. It is therefore concluded that in this flock of sheep the date of onset of the breeding season in each year is largely non-genetic. This conclusion is in agreement with most previous workers (McKenzie and Terrill, 1937; Goot, 1949; DeBaca *et al,* 1954) but is in disagreement with Kelly and Shaw (1943). In the younger flock of 18 ewes there was a suggestion ($p=0.02$) of consistency in the onsets of the breeding seasons (table 1).

On the basis of these data it appears improbable that any progress

could be made by selecting for a prolonged breeding season in sheep of the particular genetic background used in this study.

Variations in the length of the estrous cycle

Most previous workers who studied the length of estrous cycles were impressed by the uniformity of cycle length, reporting that 80–90% of all cycles fall within the limits of 14 to 19 days inclusive and considering cycles outside this range abnormal. Most, if not all, of these workers concerned themselves with the length of the estrous cycles at the height of the breeding season, and did not have observations either at the very beginning of the season or at its very end.

A total of 2,321 estrous cycles was recorded during the three years. It became apparent early in this work that great irregularity existed in the intervals between heats early in the season and that, at that time, the majority of the cycles departed significantly from the usually accepted interval of 16 days. Special precautions were taken to check the records and observations of the persons responsible for the work. In one season the regular caretaker was replaced by a student who had considerable experience with sheep and who was unaware that cycles may deviate significantly from the generally accepted interval of 16 days. Because his observations and those of the person in charge of the experiment coincided during the three years the tests were in progress there is no reason to assume that the data are not typical of the normal breeding behavior of such sheep.

The intervals between heats deviated substantially from the mean of 16 days both early in the season and at its conclusion (table 2). In 1951 the normal cycle length was not reached by the majority of the animals until September, while in 1952 it was reached in August. For reasons which are not clear the average "normal" cycle length was 17.5 days in 1951 but only 15.5 days in 1952. It is interesting that in 1953 the average onset of the breeding season was later than in the previous two years. In that year no abnormally long or short cycles were observed early in the season and the average cycle length for all cycles was approximately 17 days. Because the ewes were killed before the conclusion of the breeding season, no information is available on the length of late cycles in the season.

In each of the three years an appreciable number of sheep had their first heats much later than the ewes showing early heats. In each of the three years, the later the first heat the more likely it was to be followed

TABLE 2. COMPARISON OF LENGTH AND FREQUENCY OF CYCLES IN TWO DIFFERENT YEARS

Month	1951						1952					
	Number of cycles	Percent of cycles			Average cycle length		Number of cycles	Percent of cycles			Average cycle length	
		Normal	Long	Short	Days	SD[a]		Normal	Long	Short	Days	SD[a]
May	12	33	67	0	33.5	8.43	0					
June	54	15	76	9	60.5	4.77	7	26	71	3	56.5	12.74
July	39	10	79	11	33.5	2.59	10	30	60	10	31.5	5.47
August	48	55	33	12	21.5	1.40	51	54	21	25	16.5	0.85
September	134	80	14	6	17.5	0.47	196	66	9	25	15.5	0.39
October	166	83	12	5	17.5	0.31	209	73	7	20	16.0	0.26
November	153	89	9	2	17.5	0.32	212	81	4	15	16.0	0.26
December	177	90	7	3	17.5	0.25	217	75	6	19	16.0	0.29
January	142	77	19	4	19.0	0.58	231	41	12	47	14.0	0.43
February	48	69	29	2	19.5	0.84	108	24	38	38	17.0	0.78
March	10	10	90	0	33.0	3.76	11	9	0	91	11.5	0.84

[a] SD—standard deviation.

by the expected 16-day interval. Intervals between heats in ewes in which the first heat occurred in September or October almost invariably fell within the normal range of 14 to 19 days. Normality of cycle length in one year did not preclude abnormality in either the previous or the succeeding years. Similarly, ewes which terminated the breeding season early (November and December) were less likely to have cycles outside the 14-to-19 day range than did ewes which continued to come into heat until February or March.

Cycles of abnormal length made up 32.5% of all cycles, and comprised 358 cycles longer than 19 days and 397 cycles shorter than 14 days. In 1951 the majority of cycles outside the range of 14 to 19 days was longer than 19 days, while in 1952 the majority of these cycles was shorter than 14 days. Whether this difference is due to the age of the ewes or the difference in the onset of the breeding season remains unknown. The duration of some of the long cycles was a multiple of 16 which made it seem possible that heats had been missed by the observers or the ram. However, 82% of the long cycles were not multiples of 14–19 days and deviated significantly in length from cycles in that range. In 1951, 25% of the cycles and in 1952, 38% of the cycles fell outside of the 14–19 day range. In 1951 the long cycles averaged 40.9 ± 0.65 days (range: 20–127 days) while in 1952 their average length was 27.7 ± 2.93 days (range: 20–72 days). The short cycles in the two years averaged 10.7 ± 0.41 days and 9.4 ± 0.01 days respectively. In both years the range of short cycles was from 3–13 days.

The fact that these abnormally short and long cycles occur predominantly in sheep which come into heat earlier than the majority, and the fact that such cycles are most frequent very early and very late in the breeding season, suggests that they may be caused by endocrine imbalance. Kammlade *et al.* (1952) showed that the gonadotrophic potency of sheep pituitaries rises significantly during the non-breeding season. Ewes injected with gonadotrophic hormones show increased variability in the length of the estrous cycle. It is possible that, in those ewes which are most sensitive to the factors responsible for the onset of the breeding season (e.g. decreasing light), the pituitary hormone level most compatible with normal reproductive function does not occur until the sheep have been exposed to the stimulus for a considerable time. The periods during which the pituitary gland responds to external stimuli by adjusting the rate of production of gonadotrophic hormone may be the periods during which cycles of abnormal length are most common.

Summary

A flock of 100 Western ewes was checked for heat daily for three consecutive years. The data showed no tendency of individual ewes to be consistently early or late with regard to the onset of the breeding season. Therefore no progress can be made in sheep of this genetic background in attempting to select for prolonged or continuous breeding seasons.

Of 2,321 cycles, 32.5% were longer than 19 days or shorter than 14 days. The great majority of these "abnormal" cycles was observed very early or very late in the breeding season, when the frequency of abnormal cycles was significantly higher than those of the cycles falling within 14–19 day range.

Ewes which do not come into heat until late August or September tend to have first cycles within the normal range of 14 to 19 days. The earlier a ewe terminates the breeding season the less likely she is to have terminal cycles of abnormal length.

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FECAL ELIMINATION OF HORMONES IN SHEEP AND CATTLE TREATED WITH SYNTHETIC ESTROGENS [1, 2]

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IN the past, fecal elimination of estrogens has been of interest mainly from an academic point of view. However, with the extensive oral treatment of cattle with diethylstilbestrol, estrogenic residues in fecal material take on practical significance. This study was undertaken to determine 1) the presence of estrogen in the feces of cattle and sheep treated orally and subcutaneously with estrogens and 2) the effect of these residues on swine following hormone treated cattle.

Experimental Procedure

The feces were dried at approximately 200° F. and ground in a Waring blender. The dried, ground material was extracted by refluxing with 95% ethyl alcohol for one hour. These alcoholic extracts were poured over an amount of ration equivalent to the weight of the dried fecal sample and oven dried. After drying, this material was fed to castrated Rockland-Swiss female mice at the rate of three grams per mouse daily for six days. The mice were sacrificed on the seventh day, their uteri removed, slit lengthwise and weighed (Stob *et al.*, 1954).

Standard mouse ration, over which alcoholic solutions of hormones had been sprayed at varying dose levels was fed at the rate of three grams per mouse daily for six days. On the seventh day, the mice were sacrificed and their uteri removed and weighed. Consumption of feed to which fecal extracts or alcoholic solutions of hormones had been added was equal.

Results

Uterine Weight Response to Different Estrogens

The use of three different synthetic estrogens in the cattle experiments and two synthetic estrogens in the sheep trial necessitated the determination of the response of mice to these various hormones when

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[2] This study was supported in part by a grant by Eli Lilly and Co.
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they were added to the feed. These data are presented in table 1. Under the conditions of this experiment the most potent estrogen for mice is diethylstilbestrol followed by dienestrol and the least potent is hexestrol.

Efficiency of Extraction Procedure

The efficiency of alcoholic extraction of material for estrogens was tested by refluxing feed to which a known amount of hormone had been added, assaying this extracted feed, assaying a sample of feed to which the extract was added and comparing both to assays of feed to

TABLE 1. UTERINE WEIGHT RESPONSES (in mg.) OF CASTRATED FEMALE ROCKLAND-SWISS MICE TO ORAL ESTROGENS

Hormone per gram feed	Diethyl-stilbestrol	Dienestrol	Hexestrol
mcg.			
...	18.76(10)[a]	17.58(12)	17.58(12)
.01	28.49(9)	16.18(10)	15.60(10)
.04	77.00(9)	23.88(10)	21.80(10)
.08	112.40(9)	47.64(10)	25.80(10)
.16	119.62(9)	98.78(10)	34.69(9)
.20	160.73(9)	101.16(10)	37.33(9)
.30	144.76(9)		
.40		115.69(10)	87.40(10)
.80			80.34(10)

[a] Figures in parentheses indicate number of female mice in each group.

which hormone had been added and also control diet. Although the extraction procedure is not completely efficient, it can be seen that most of the original activity was recovered. These data are presented in table 2.

Sheep Fecal Estrogens

Fecal collections were made at two-week intervals following the initiation of estrogen treatment. Five mice were used for the assay of each collection except the control groups at 14, 28 and 42 days where four animals were used.

The data presented in table 3 show that the feces from sheep treated with a progesterone-estradiol hormone combination had no more estrogenic activity than did those from control lambs except at the last collection. This is of doubtful significance however, because of the unusually low control uterine weights at this time. Feces of lambs

TABLE 2 EFFICIENCY OF EXTRACTION PROCEDURE

Treatment	No. of mice	Body wt.	Uterine wt.
		gm.	mg.
Control feed	10	26.00	19.14
Extracted control feed	10	26.40	19.80
Control feed plus extract of control feed	10	25.00	23.90
Diethylstilbestrol, .08 mcg. per gram feed	10	26.50	121.74
Extracted feed to which .08 mcg. diethylstilbestrol had been added per gram feed	10	25.40	28.22
Control feed plus the extract of feed to which .08 mcg. diethylstilbestrol had been added per gram feed	9	24.22	94.91

implanted with a 12 mg. pellet of diethylstilbestrol contained greater amounts of estrogen one month after implantation than immediately after treatment; subsequent to this however, there was a gradual reduction in the amount of fecal hormone. Sheep treated orally with dienestrol eliminated relatively high amounts of estrogen throughout the experiment.

Cattle Fecal Estrogens

The assay of the feces from a group of Hereford steers treated orally with 10 mg. daily of diethylstilbestrol, dienestrol or hexestrol and a second group of Shorthorn steer and heifer calves which received the

TABLE 3. UTERINE WEIGHT RESPONSE (in mg.) TO FECAL HORMONES FROM SHEEP TREATED WITH ESTROGENS AND PROGESTERONE

	Days after treatment				
Treatment	14	28	42	56	70
Control	25.60	25.75	21.70	23.12	10.84
Diethylstilbestrol, 12 mg. pellet	52.72**	116.96**	60.80**	37.72**	25.52**
Estradiol plus progesterone pellet	24.32	25.40	21.12	20.52	20.12**
Dienestrol, 2 mg. daily, orally	148.92**	124.00**	128.20**	136.52**	135.45**
Dienestrol, 4 mg. daily, orally	132.12**	104.80**	128.00**	115.64**	115.84**

** $P<0.01$.

TABLE 4. UTERINE WEIGHT RESPONSE (in mg.) TO FECAL HORMONES FROM CATTLE TREATED WITH SYNTHETIC ESTROGENS

Daily hormonal treatment of cattle	No. of mice	Body wt.	Uterine wt.	% of body wt.
		gm.	mg.	
Herefords, 1954				
Control	5	26.20	24.76	.095
Diethylstil-bestrol, 10 mg.	5	23.80	152.50**	.640**
Dienestrol, 10 mg.	5	25.80	122.36**	.482**
Hexestrol, 10 mg.	5	24.40	99.12**	.405**
Shorthorns, 1954–55				
Control	5	22.80	16.32	.072
Diethylstil-bestrol, 10 mg.	5	23.00	103.16**	.449**
Dienestrol, 10 mg.	5	24.60	121.60**	.497**
Hexestrol, 10 mg.	5	23.40	109.24**	.466**

** $P<0.01$.

same estrogen treatment indicate a fairly high but not consistent elimination of hormone. These data are presented in table 4.

Performance of Gilts Following Hormone Treated Steers

On Dec. 23, 1954, sixteen crossbred Chester White-Yorkshire gilts averaging 75 lb. were placed in four lots of cattle receiving estrogens orally. In order to insure maximum fecal intake the gilts were fed only 2 lb. of corn per gilt daily. They remained in the cattle lots for 140 days until they averaged 190 lb. Upon removal from the cattle lots they were placed on pasture and a Chester White boar was allowed to

TABLE 5. FARROWING PERFORMANCE OF GILLS FOLLOWING CATTLE TREATED WITH SYNTHETIC ESTROGENS

	Daily hormonal treatment of cattle			
	Control	10 mg. diethyl-stilbestrol	10 mg. dienestrol	10 mg. hexestrol
Total no. gilts	4	4	4	4
No. of gilts farrowing	3	2	4	3
No. gilts failing to settle	1	2	0	1
Total no. pigs	25	18	42	26
Av. litter size	8.3	9.0	10.5	8.6
Av. pig wt., lb.	2.8	2.6	2.6	2.9
Total no. dead pigs farrowed	0	0	4	2

run with the gilts constantly. In order to make some estimate of reproductive efficiency, the boar was removed after three weeks. Presumably, all the gilts would come into heat at least once during this period. Of the twelve gilts farrowing, eight conceived during this period, probably on first service. The remaining four gilts which farrowed were hand bred and all settled as a result of this second service. Of the four gilts which did not farrow, three failed to come into heat and one was bred repeatedly but failed to settle. The farrowing record as shown in table 5 indicates that all treatments gave similar results.

Effect of Fecal Hormones on Boar Pigs

One boar pig and two gilts were placed in each of four lots of Hereford steers receiving either estrogen or androgen or a combination of the two orally. These pigs were also limited to 2 lb. of corn daily to

TABLE 6. TESTES SIZE OF BOAR PIGS FOLLOWING STEERS TREATED WITH ESTROGEN AND ANDROGEN

Daily hormonal treatment of cattle	Body wt. of pigs	Testes wt.
	lb.	gm.
Control	84	120
Diethylstilbestrol, 10 mg.	55	19
Diethylstilbestrol, 5 mg. plus 50 mg. methyl testosterone	78	30
Methyl testosterone, 175 mg.	102	26

encourage fecal consumption. Their average weight at the beginning of the experiment was 35 lb. After 114 days they were removed from the cattle lots when they averaged 80 lb. and the testes were removed from the males. Although these data may be criticized for lack of numbers they are presented in table 6. Histological examination of the testes confirmed gross observations regarding lack of development in the testes of the boars in the lots of cattle receiving hormone. These results can be explained on the basis of suppression of gonadotrophic hormone elaboration by the pituitary due to exogenous hormone found in the feces of the cattle.

Discussion

Most of the pertinent literature regarding fecal estrogens prior to 1945 has been reviewed by Levin (1945) who demonstrated the presence of estrogens in the feces of pregnant cows. Pearlman *et al.* (1947) were

able to detect estrogen in the bile of pregnant cows, this biliary estrogen presumably being the source of the fecal estrogen.

The role of the liver in the metabolism of estrogens is well known. Using radioactively labelled diethylstilbestrol, Hanahan *et al.* (1953) demonstrated that the main pathway of absorption of oral estrogens in rats is the portal system and that more than 50% of the administered radioactivity was present in the feces. In our experiment the relatively high estrogenic activity of the feces of lambs treated with a 12 mg. pellet of diethylstilbestrol could be explained on the assumption that subcutaneously administered hormone does not necessarily pass through the liver in its way to the feces whereas orally administered hormone does.

No attempt was made to estimate the quantity of estrogen eliminated in the feces in terms of amounts of hormone administered for several reasons. A more precise schedule of fecal collection than was employed by us would be required. The well known fact that estrogen is eliminated in combined forms of low biological potency makes quantitative determinations difficult.

Although estrogens were recovered in significant amounts in the feces of hormone-treated cattle, under the conditions of this experiment they were not present in sufficient quantity to impair the reproductive performance of gilts exposed to them. No attempt was made to breed the gilts while they were in the cattle lots so it is not known if they came into heat during this time. They did show definite swelling and hyperemia of the vulva and mammary enlargement. Stevenson and Ellis (1953) reported that the oral treatment of gilts with from 2.5 mg. to 250 mg. diethylstilbestrol daily suppressed estrus but did not permanently impair their reproductive ability. From the response of the boar pigs one could conclude that elaboration of gonadotrophic hormone by the pituitary is suppressed during the time of exposure to fecal estrogens.

Summary

Estrogens were found in the feces of sheep treated with diethylstilbestrol subcutaneously and dienestrol orally as well as in the feces of cattle treated orally with diethylstilbestrol, dienestrol and hexestrol.

Under the conditions of this experiment, gilts following hormone treated cattle were not impaired reproductively. On the basis of testicular response of boars there was a suppression of pituitary gonadotrophic hormone elaboration while the hogs were following the cattle.

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RESIDUAL ESTROGEN IN THE TISSUES OF CATTLE TREATED ORALLY WITH DIETHYLSTILBESTROL, DIENESTROL, HEXESTROL AND CHLORTETRACYCLINE [1]

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RECENT publication of data concerning retention of estrogens in tissues of hormone treated cattle has indicated that the degree of residual activity may differ depending on the dose level, route of administration and type of tissue assayed.

The experiments reported here were designed to determine the degree of residual estrogenic activity in five different tissues of cattle treated orally with three synthetic estrogens and chlortetracycline.

Materials and Methods

The tissues assayed were obtained from two experimental groups of cattle; one a group of Shorthorn steer and heifer calves whose daily treatment by lot consisted of the control lot receiving no hormone and three additional lots receiving 10 mg. diethylstilbestrol, dienestrol or hexestrol orally. The second group of cattle was two year old Herefords treated daily, singly and in combination, with 12 mg. hexestrol and 100 mg. chlortetracycline per steer. The control lot received neither hormone nor antibiotic. In both groups hormone was administered up to the time of shipment for slaughter. Tissues were obtained from five cattle in each lot and the assays were run on a composite sample of each tissue.

Tissues assayed were liver, kidney, kidney fat and muscle, comprised of the entire section through the 11th and 12th rib. A sample of the gastro-intestinal tract consisting of approximately equal parts by weight of reticulum and small intestine, washed at the time of collection, was also assayed. For the sake of convenience, this sample shall subsequently be referred to as intestine. The kidney and liver were dried at room temperature for 10 days, the intestine for 7 days and the muscle, 3 days. No attempt was made to dry the fat. The kidney, liver and intestine were fed without adding any diluent. The muscle and fat from

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the Shorthorns were fed in a ratio of 5 parts of tissue to 1 part mouse ration. A ratio of 4 parts tissue to 1 part mouse ration was used in assaying the muscle and kidney fat from the Hereford experiment because the body weights of the test mice were not maintained satisfactorily when a 5 to 1 ratio was employed. In the second experiment, in

TABLE 1. ASSAY OF SHORTHORN CALF TISSUES FOR RESIDUAL ESTROGENIC ACTIVITY

Tissue assayed	No. of mice	Mean body weight	Mean uterine weight	% body weight
		gm.	mg.	
Muscle				
Control	9	28.00	14.24	.051
Stilbestrol	10	27.10	16.96*	.064
Dienestrol	10	27.60	14.96	.054
Hexestrol	10	26.90	15.14	.056
Kidney fat				
Control	10	21.90	12.40	.058
Stilbestrol	10	20.90	15.58*	.076*
Dienestrol	10	20.20	14.32	.071*
Hexestrol	10	20.70	14.94	.073*
Liver				
Control	10	27.10	20.70	.078
Stilbestrol	10	24.80	45.38**	.184**
Dienestrol	10	27.30	32.34**	.118**
Hexestrol	10	29.90	22.38	.076
Intestine				
Control	10	33.50	20.68	.062
Stilbestrol	10	32.30	39.14**	.121**
Dienestrol	10	30.60	32.50**	.107**
Hexestrol	10	30.00	21.16	.071
Kidney				
Control	10	28.50	18.36	.064
Stilbestrol	9	33.80	74.40**	.216**
Dienestrol	10	32.00	75.46**	.238**
Hexestrol	10	28.30	30.14*	.108*

** $P<0.01$, * $P<0.05$.

order to confirm satisfactory maintenance of body weight, the mice were weighed at the beginning and end of the assay period.

The tissues were assayed using the technique described by Stob *et al.* (1954a) with two modifications. In all cases the test mice were restricted to 3 gm. of test material per mouse daily rather than *ad libitum* feeding. The length of the assay period varied as follows: the muscle and kidney fat from the Shorthorns were fed for 10 days. The kidney, liver and intestinal tissues were fed for 8 days due to a shortage of

tissue. All the tissues from the Herefords were fed for a 6 day period.

Differences in uterine response were tested for statistical significance using the method of analysis of variance (Snedecor, 1946).

TABLE 2. ASSAY OF HEREFORD STEER TISSUES FOR ESTROGENIC RESIDUES

Tissue assayed	No. of mice	Mean body weight		Mean uterine weight	% body weight
		gm.	gm.	mg.	
		3–2–56	3–8–56		
Liver					
Control	10	27.50	26.80	16.74	.063
Hexestrol	9	27.00	26.00	17.33	.067
Chlortetracycline	10	26.30	25.10	15.66	.062
Combination	10	27.10	26.80	16.72	.062
Kidney					
Control	10	28.10	31.20	19.26	.062
Hexestrol	10	27.40	31.50	20.10	.064
Chlortetracycline	10	29.40	32.30	23.84	.074
Combination	10	29.20	31.80	24.08	.076
		3–9–56	3–15–56		
Muscle					
Control	10	29.30	31.70	21.72	.067
Hexestrol	10	28.20	31.80	19.86	.062
Chlortetracycline	10	27.60	31.60	20.82	.066
Combination	9	28.33	32.11	21.51	.068
Intestine					
Control	10	27.90	30.30	21.50	.071
Hexestrol	10	28.00	29.00	20.82	.072
Chlortetracycline	10	27.00	28.70	21.82	.077
Combination	10	25.80	28.00	18.80	.068
Kidney fat					
Control	10	27.80	27.10	19.30	.072
Hexestrol	10	28.00	27.60	22.58**	.082*
Chlortetracycline	10	28.90	28.70	20.62	.072
Combination	10	27.00	26.20	20.62	.078
Standard mouse ration	10	27.70	25.80	20.78	.080

** $P<0.01$, * $P<0.05$.

Results

The data secured from the assay of the tissues from the Shorthorn calves are presented in table 1. These data indicate that there was a statistically significant increase in the uterine weights of the mice fed the tissues from cattle treated with diethylstilbestrol. The administration of dienestrol caused a significant increase in uterine weight when

liver, intestine and kidney were fed. Only the kidney of hexestrol-treated cattle contained detectable amounts of estrogenic activity. When the uterine weights were expressed as a percentage of body weight, there was significant residual estrogenic activity in the kidney fat of dienestrol and hexestrol-treated cattle.

In table 2 are presented the results of assaying the tissues from cattle treated with hexestrol and chlortetracycline. Four purposes of statistical analysis, the tissues from cattle receiving neither hormone nor antibiotic

TABLE 3. EFFECT OF TIME ON UTERINE WEIGHT RESPONSE OF CASTRATED FEMALE MICE FED 0.0055 mcg. DIETHYLSTILBESTROL PER GRAM OF FEED

Days on treatment	No. of mice	Mean body weight	Mean uterine weight	% body weight
		gm.	mg.	
0—control	10	27.50	22.50	.082
1	10	26.60	24.68	.093
2	10	25.40	24.86	.098
3	10	26.10	27.02**	.104
4	10	25.40	22.88	.091
5	10	27.20	26.32*	.097
5—control	10	27.10	22.46	.083
6	10	27.50	26.40	.098
7	10	26.50	26.32*	.100
8	10	24.00	24.94	.104
9	10	25.70	25.80*	.101
10	10	25.20	27.76*	.110
10—control	10	26.10	22.84	.088

** $P<0.01$, * $P<0.05$.

served as the control for the tissues of the cattle treated only with hormone. The tissues from the cattle receiving only antibiotic served as the control for the tissues from the cattle receiving the antibiotic-hormone combination. These data indicate that in the majority of cases the tissues from the hormone-treated cattle yielded heavier uterine weights than the controls but these increases were statistically significant only in the case of the kidney fat. Inspection of the body weights of the mice indicates that some groups on the experimental diets lost weight but this loss was not as great as that seen in the group fed the standard mouse ration.

The question might arise as to whether a 6-day assay period was of sufficient length to elicit a uterine response. In an attempt to provide the answer, 0.0055 mcg. of diethylstilbestrol was added per gram of mouse

ration and was fed to a group of 100 castrated, female Rockland-Swiss mice, 10 of which were sacrificed daily for a 10 day period. This level of hormone had previously been shown to be the minimum required to elicit a consistent, statistically significant increase in uterine weight (Stob *et al.*, 1954a). Uterine weights were also obtained from 3 groups of mice which had not been exposed to hormone. These control mice were sacrificed at the beginning of the experiment and 5 and 10 days after the initiation of hormone feeding to the treated groups. The results of this trial, presented in table 3, indicate that only three days of hormone feeding were required to elicit a statistically significant increase in uterine weight.

Discussion

The subcutaneous implantation of diethylstilbestrol has been shown to result in detectable residual estrogenic activity in the meat of cattle and sheep depending upon the dosage (Stob *et al.*, 1954b). Perry *et al.* (1955) reported that the oral administration of synthetic female hormone-like compounds does not result in estrogen retention in the tissues of cattle so treated. The data reported here confirm the absence of estrogens in the muscle tissue of cattle treated orally with dienestrol and hexestrol. However, in contrast to the earlier work, residual estrogenic activity was found in the muscle of cattle treated with diethylstilbestrol.

The detection of residual estrogens in the tissues of diethylstilbestrol-treated cattle is in partial agreement with Turner (1956) who reported a non-significant increase in the uterine weights of mice fed a variety of tissues from cattle treated with this synthetic estrogen. Preston *et al.* (1956) failed to detect any residual estrogenic activity in the tissues of cattle treated orally with diethylstilbestrol.

The failure to detect estrogenic residues in most of the tissues of hexestrol- or hexestrol-chlortetracycline-treated cattle may be due to the fact that this estrogen has a low estrogenic potency or reduced oral effectiveness. If hexestrol has a low estrogenic potency *per se*, in view of the growth response of cattle to this hormone being equal to that produced by diethylstilbestrol (Perry *et al.*, 1956), hexestrol may be the hormone of choice. However, unpublished data from this laboratory indicates that based on the mouse uterine response, hexestrol has a reduced oral potency compared to diethylstilbestrol. The possibility definitely exists that the amount of residual estrogen in the tissues of hexestrol-treated cattle is similar to that in the tissues of diethylstilbestrol-treated cattle.

The knowledge that the time required in feeding tissues for assay may be reduced is of value in the event that the amount of tissue available for assay is small. Except for reduced uterine weights taken on the fourth day after the initiation of hormone feeding, for all practical purposes the uterus reached its maximum weight in response to the administered level of hormone three days after feeding began and was maintained at this weight.

Summary

Estrogenic residues were detected in the muscle, kidney fat, kidney, intestine and liver of cattle treated orally with diethylstilbestrol. Residual estrogenic activity was present in the kidney, kidney fat, intestine and liver of cattle following oral treatment with dienestrol. The oral administration of hexestrol to cattle resulted in the retention of estrogen only in the kidney and kidney fat of these animals.

The oral administration of chlortetracycline in combination with hexestrol had no apparent effect on the degree of residual estrogenic activity.

The minimum length of time required for the uterus of the castrated female mouse to respond statistically significantly to a minute amount of orally administered diethylstilbestrol is three days.

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THE EFFECT OF VARIOUS HORMONE IMPLANTS ON FATTENING LAMBS [1]

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IMPLANTS of stilbestrol have been shown by many workers to consistently increase rate of gain and feed efficiency in fattening lambs (Andrews *et al.*, 1949; Jordan, 1950). However, lower carcass grade, prolapse of the rectum and urinary blockage have been associated with the stilbestrol treatment, Jordan (1953). Galloway *et al.* (1952) implanted lambs with a combination of estradiol and progesterone and reported a significant increase in rate of gain and feed efficiency with no lowering of carcass grade and yield or any adverse side effects. Jordan (1954) using the same treatment, reported a lower carcass grade and an earlier closure of the epiphysis joint among the treated lambs.

Two trials were conducted during the spring and summer of 1955 to determine whether a combination of testosterone and estradiol, or progesterone and estradiol would mask the undesirable effects of the estradiol without preventing or minimizing the stimulation of growth rate due to the estradiol.

Experimental Procedure

In the spring trial, 50 lambs were randomly allotted into five lots of 10 lambs each. They were sheared before being placed on trial and all lambs were full-fed corn, alfalfa hay and 0.1 lb. of soybean oilmeal per lamb daily. The following implant treatments were superimposed: Lot 1, controls; Lot 2, 12 mg. stilbestrol; Lot 3, 25 mg. testosterone and 5 mg. estradiol; Lot 4, 50 mg. testosterone and 10 mg. estradiol; Lot 5, 250 mg. progesterone and 10 mg. estradiol.

In the summer trial, 60 high quality California feeder lambs were randomly allotted into six lots of 10 lambs each. They were sheared and full fed corn, alfalfa hay and 0.1 lb. of soybean oilmeal per lamb daily. The following treatments were superimposed: Lot 1, control; Lot 2, 200 mg. progesterone and 5 mg. estradiol; Lot 3, 200 mg. progesterone

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and 2.5 mg. estradiol; Lot 4, 25 mg. testosterone and 5 mg. estradiol; Lot 5, 30 mg. testosterone and 5 mg. estradiol; Lot 6, 25 mg. testosterone and 2.5 mg. estradiol.

Results and Discussion

Spring Trial

The results of this trial are shown in table 1. Implants of 12 mg. stilbestrol and both levels of the combination of testosterone and estradiol significantly increased the average daily gain. The combination of

TABLE 1. EFFECT OF HORMONE IMPLANTS ON FATTENING LAMBS
Feb. 2–April 27, 1955

	Control [a] Lot 1	Stil. Lot 2	Estradiol-testosterone Lot 3	Estradiol-testosterone Lot 4	Estradiol-progesterone Lot 5
No. lambs	10	10	10	10	10
Initial av. wt., lb.	63.3	64.1	63.8	64.0	63.9
Final av. wt., lb.	100.7	107.0	107.5	107.2	104.0
Gain/lamb, lb.	37.4	42.9	43.7	42.9	40.0
No. days fed	84	84	84	84	84
Av. daily gain, lb.	.445	.517	.520	.517	.476
Av. daily feed consumption, lb.					
Grain	1.42	1.40	1.42	1.43	1.40
Hay	1.84	1.82	1.81	1.85	1.82
Protein supplement	.10	.10	.10	.10	.10
Feed/100 lb. gain, lb:					
Grain	319.3	274.8	272.8	280.0	294.8
Hay	413.1	356.4	348.7	363.0	381.5
Protein supplement	22.5	19.6	19.2	19.6	21.0
Carcass data					
Yield, %	49.5	48.9	47.8	47.9	47.9
Grade [b]	4.5	3.5	3.3	3.9	3.0

[a] Lot 1—Control, Lot 2—Implant of 12 mg. stilbestrol, Lot 3—Implant of 5 mg. estradiol and 25 mg. testosterone, Lot 4—50 mg. testosterone and 10 mg. estradiol, and Lot 5—Implant of 10 mg. estradiol and 250 mg. progesterone.

[b] Choice, 8, good 5, and utility 2.

progesterone and estradiol (Lot 5) increased the daily gain slightly but the increase was not sufficient to be significant. The data suggest that the progesterone inhibited the growth acceleration from the estradiol to a greater extent than the testosterone at the levels used. The experimental design does not lend itself to statistical analysis of feed consumption. However, none of the treatments appeared to affect average feed consumption. Carcass grade and yield in all of the treated lots were lower than the control lambs. However, no one treatment appeared to exert a greater depression on carcass grade or yield than another.

Neither testosterone nor progesterone prevented the estradiol from adversely affecting the secondary sex glands of the lambs. Wether lambs treated with progesterone and estradiol (250 mg. progesterone and 10 mg. estradiol) showed the greatest amount of proliferation of the prostate and cowpers glands. The cowpers glands were about the size of small walnuts and were filled with an extremely heavy, clear fluid. While no blockage of the urinary tract occurred in any of the lambs, the diameter of the ureter of these treated lambs was decidedly less than in

TABLE 2. EFFECT OF VARIOUS HORMONES ON FATTENING LAMBS
May 27–July 22, 1955

	Control Lot 1	200 Prog. 5 Est. Lot 2	200 Prog. 2.5 Est. Lot 3	25 Test. 5 Est. Lot 4	30 Test. 5 Est. Lot 5	25 Test. 2.5 Est. Lot 6
No. lambs	10	10	10	10	10	10
Initial av. wt., lb.	70.3	69.8	71.9	67.6	68.5	71.5
Final av. wt., lb.	96.1	97.1	97.6	95.6	95.3	98.0
Gain/lamb, lb.	25.8	27.3	25.7	28.0	26.8	26.5
No. days fed	56	56	56	56	56	56
Av. daily gain, lb.	.461	.488	.459	.500	.479	.473
Av. daily feed consumtion, lb.						
Grain	1.43	1.40	1.45	1.29	1.36	1.20
Hay	1.72	1.72	1.76	1.66	1.71	1.58
Protein supplement	.1	.1	.1	.1	.1	.1
Feed/100 lb. gain, lb.						
Grain	310	287	316	258	284	254
Hay	373	352	383	332	357	334
Protein supplement	20	20	22	20	21	21
Carcass data						
Yield, %	51.9	52.3	51.9	50.9	51.3	51.7
Grade[a]	8.22	8.12	7.33	7.20	6.70	7.33

[a] Choice 8, good 5, and utility 2.

the control lambs. The combination of 25 mg. testosterone and 5 mg. estradiol caused the second greatest effect on the cowpers gland, prostate, and ureter; followed by 12 mg. of stilbestrol and the combination of 50 mg. of testosterone and 10 mg. of estradiol. Bell (1953) reported similar effects when 12 mg. of stilbestrol was implanted into feeder lambs.

Summer Trial

The results of this trial (table 2) indicate that the increase in growth rate from hormone implants was not as great in this trial as during the spring trial. Only the lambs receiving 25 mg. of testosterone and 5 mg. of estradiol (Lot 4) gained materially faster than the controls. A comparison of Lots 2 and 3 (progesterone and estradiol) with Lots 5 and 6

(testosterone and estradiol) suggests that progesterone reduced the growth stimulation from estradiol to a greater extent than testosterone when used at these levels. This same trend was evident during the spring trial. Examination of carcass data shows no evidence of a lowering of carcass yield. However, with the exception of Lot 2 (200 mg. of progesterone and 5 mg. of estradiol) carcass grades of the hormone treated lambs were approximately ⅓ of a grade lower than the control lambs. Jordan *et al.* (1955) reported no lowering in carcass grade of feeder lambs when similarly treated with progesterone and estradiol. However, in both of these trials, hormone implants lowered the carcass grade, illustrating the inconsistency of response that so frequently occurs when hormone implants are administered to lambs.

Summary

In a trial conducted during the early spring with feeder lambs, increased rate of gain and feed efficiency occurred in all lambs treated with various combinations of hormone implants. However, without exception, carcass grade and yield were lower in the treated groups than in the control groups. At the levels used in this experiment, neither progesterone nor testosterone protected the lambs from the adverse side effects of estradiol. However, when used in combination with estradiol progesterone reduced the increased rate of gain to a greater degree than the testosterone estradiol combination.

Lambs treated during the summer months with combinations of estradiol and testosterone, and estradiol and progesterone responded to a very slight degree as measured by rate of gain and feed efficiency. Carcass grade, however, was decidedly lower in all groups except one (200 mg. progesterone and 5 mg. estradiol). As was the case in the spring trial, progesterone reduced growth stimulation from estradiol to a greater extent than did testosterone. The inconsistent effects of estrogen implants on secondary sex glands and particularly carcass grade and yield limits their use and suggests the need for additional research.

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THE EFFECT OF VARIOUS LEVELS OF ORALLY ADMINISTERED METHYL TESTOSTERONE ON GROWTH AND CARCASS COMPOSITION OF SWINE [1]

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PREVIOUS results at this station (Beeson *et al.*, 1955) indicated that a daily intake of an average of 20 mg. of methyl testosterone by growing and fattening swine resulted in carcasses which contained heavier lean cuts and lighter fat cuts than carcasses from similar hogs which had received no hormone. The feeding of methyl testosterone had no effect on the growth rate of hogs in a ration containing no antibiotic but significantly decreased the growth rate of hogs in diets with an antibiotic. Sleeth *et al.* (1953) and Woehling *et al.* (1951) reported no effect on the growth rate of swine from implantation of testosterone propionate. Similarly, no difference in carcass quality could be attributed to the treatment.

Since only one level of methyl testosterone was fed in the Purdue trials (Beeson *et al.*, 1955), it was desirable to test the effect of various levels of methyl testosterone in the diets of growing-fattening swine.

Experimental Procedure

Eighty weanling Duroc pigs averaging 51 lb. liveweight were stratified by weight and divided into 8 lots of 10 each and were fed in drylot a ration composed of shelled corn, protein supplement and minerals on a free-choice basis. The composition of the basal protein supplement and mineral mixture is shown in table 1.

Lot I served as the control and received only the basal ration. In Lots II through VIII, levels of 10, 20, 30, 40, 50, 60 and 70 mg. of methyl testosterone were incorporated, respectively, per pound of protein supplement.

Each hog was slaughtered between 210 and 220 lb., and standard carcass measurements and weights of the primal cuts were obtained. All data was analyzed for least significant mean differences by accepted methods of statistical analyses.

[1] Contribution from the Department of Animal Husbandry, Journal Paper No. 965 Purdue University, Agricultural Experiment Station, Lafayette, Indiana.

Results and Discussion

Effect of Methyl Testosterone on Growth Rate

As shown in table 2, a daily intake of 9 mg. of methyl testosterone had no effect on the growth rate of pigs in the weight range of 51 to 187 lb. However, an intake of 17 mg. per day resulted in apparent growth depression; higher levels (27 to 62 mg. per day) resulted in highly significant growth depression.

Although the growth depressing effect with increasing levels of methyl testosterone intake appeared to be rectilinear, actual plotting of the data

TABLE 1. COMPOSITION OF BASAL PROTEIN SUPPLEMENT AND MINERAL MIXTURE

Ingredients	Pounds
Free-choice protein supplement	
Soybean oil meal, lb.	491.5
Meat scraps, lb.	400
Dehydrated alfalfa meal, lb.	100
Antibiotic and B_{12} supplement, lb.[a]	8.5
Riboflavin, gm.	25
Calcium pantothenate, gm.	125
Niacin, mg.	100
Free-choice mineral mixture	
Steamed bonemeal, %	40
Ground limestone, %	40
Iodized salt, %	20

[a] A commercial source of oxytetracycline and Vitamin B_{12} containing 3 gm. oxytetracycline and 3 mg. Vitamin B_{12}. This provided in excess of 25 gm. of oxytetracycline and 25 mg. of Vitamin B_{12} per 1000 lb. of supplement.

indicated a curvilinear effect such that within the range of dosage in this experiment, effect of added increments was less at the higher levels.

Beeson *et al.* (1955) reported that the feeding of 20 mg. daily of methyl testosterone with a ration containing no antibiotic had no effect on growth rate (control 1.47 lb. per day; treated 1.51 lb. per day). However, when methyl testosterone was fed in a ration containing antibiotic, significant growth depression resulted (control 1.60 lb. per day; treated 1.48 lb. per day). All of the rations fed in the present experiment contained an antibiotic.

The growth data were summarized for 83 days of treatment (table 2),

the time at which the first animal was removed for slaughter. This procedure was followed because past experience has indicated that the removal of animals from a lot may have an effect on the performance of the remaining animals in the lot. All animals were continued on the assigned rations until slaughtered at approximately 210 lb., and the carcass data presented in table 3 are from the animals whose growth rates are shown in table 2.

TABLE 2. THE EFFECT OF ORAL METHYL TESTOSTERONE ON THE GAIN AND FEED EFFICIENCY OF SWINE, JUNE 7 TO AUGUST 29, 1955, 83 DAYS

	Levels of testosterone per lb. protein supplement, mg.							
	0	10	20	30	40	50	60	70
Number of pigs	10	10	10	10	10	10	10	10
Initial wt., lb.	51	51	51	51	51	51	51	51
Final wt., lb.	187	187	176	170	168	165	161	162
Total gain, lb.[a]	136	136	125	119	117	114	110	111
Av. daily gain, lb.	1.64	1.64	1.51	1.43	1.41	1.37	1.32	1.34
	Daily feed consumption, lb.							
Shelled corn	4.52	4.69	4.12	3.64	3.67	3.30	3.39	3.46
Supplement	0.89	0.88	0.86	0.91	0.85	0.94	0.87	0.88
Mineral	.02	.02	.02	.02	.02	.02	.02	.03
Testosterone, mg.	0	9	17	27	34	47	52	62
	Feed per 100 lb. gain, lb.							
Shelled corn	276	286	272	254	260	241	256	259
Supplement	54	54	57	63	60	69	69	66
Total	330	340	329	317	320	310	325	325

[a] L.S.M.D. for gain: 5%, 13 lb.; 1%, 17 lb.

Effect of Methyl Testosterone on Feed Consumption and Feed Efficiency

Even though free-choice consumption of protein supplement containing the graded levels of methyl testosterone was fairly constant (0.85 to 0.94 lb. per day), consumption of corn decreased as the level of methyl testosterone increased. The presence of methyl testosterone in the ration did not affect palatability per se because the free-choice consumption of protein supplement in which the hormone was administered did not vary greatly between lots. However, the consumption of the corn fed free-choice was lowered in the lots consuming the higher levels of methyl testosterone.

Possibly the difference in kind of gain had at least an indirect effect on corn consumption in that the gain of the animals receiving the higher levels of methyl testosterone had a higher percentage of lean meat and less fat than the animals fed no hormone. Hogs consuming the higher

TABLE 3. THE EFFECT OF ORAL METHYL TESTOSTERONE ON CARCASS QUALITY [a]

	Levels of methyl testosterone							
Per lb. protein supplement	0	10	20	30	40	50	60	70
Per pig daily, mg.	0	9	17	27	34	47	52	62
Final wt., lb.	214	212	215	212	212	213	214	214
Market wt., lb.	212	210	213	210	211	211	213	213
Cold dressed wt., lb.	149	149	150	146	147	145	146	146
Dressing %	70.3	71.0	70.4	69.5	69.7	68.7	68.5	68.5
	Carcass measurement [b]							
Body length, lb.	30.1	30.1	30.3	30.8	31.3	31.3	31.3	31.2
Back fat—								
Last lumbar, mm.	39.2	40.1	38.5	32.1	31.2	32.4	32.2	32.5
Last rib, mm.	37.3	38.4	36.3	31.8	31.7	31.3	30.9	29.4
First rib, mm.	54.0	51.7	53.6	52.3	52.4	52.3	49.3	52.8
Av., mm.	43.5	43.4	42.8	38.7	38.4	38.7	37.5	38.2
	Weight of cuts, lb.							
Hams	26.9	27.2	28.6	28.5	28.5	28.9	28.3	28.6
Loins	22.1	20.8	21.6	22.2	22.2	22.8	22.3	22.0
Bellies	26.0	27.2	27.1	25.0	24.8	24.5	24.1	22.2
Butts	9.6	9.5	10.1	10.1	10.1	10.0	10.1	9.9
Picnics	13.2	12.8	13.9	13.7	14.2	14.0	14.8	13.7
Jowls	6.0	5.7	5.4	5.3	5.4	5.1	5.7	5.5
Fatbacks	12.2	13.7	11.4	10.8	10.3	10.6	10.4	10.4

[a] Ten animals per lot.
[b] L.S.M.D. Body length—5%, .95 in.; 1%, 1.26 in.
Back fat—
Last lumbar 5%, 1.96 mm.; 1%, 2.6 mm.
Last rib 5%, 4.97 mm.; 1%, 6.6 mm.
Bellies 5%, 2.17 lb.; 1%, 2.88 lb.
Picnics 5%, 1.13 lb.; 1%, 1.5 lb.
Fatbacks 5%, 1.90 lb.; 1%, 2.53 lb.

levels of methyl testosterone (27 to 62 mg. per day) required from 6 to 13% less corn per unit of gain than hogs receiving no hormone or than those receiving 9 or 17 mg. per day. However, since the free-choice consumption of protein supplement was very nearly the same in all lots and since the hogs fed the higher levels of the hormone gained more slowly, the trend of efficiency of conversion of the protein supplement was the reverse of that for the corn.

Effect of Methyl Testosterone on External Appearance

Animals consuming the higher levels of methyl testosterone (27 to 62 mg. per day) appeared longer and trimmer of side and jowl. This appearance was borne out by slaughter data which showed greater body length, lighter bellies and lighter jowls. This is in agreement with the previous year's work (Beeson *et al.*, 1955).

There was no ranting or boar smell evident in any of the lots. However, an alteration in the external genitalia of the females was quite evident. In females fed high levels of methyl testosterone, the lower tips of the vulvae assumed a fishhook shape, pointing upward. Johnson *et al.* (1956) reported the injection of testosterone in adult ewes resulted in significantly heavier clitorides.

Effect of Methyl Testosterone on Carcass Weights and Measurements

Each animal was marketed and slaughtered at the time its liveweight fell within the range of 210 to 220 lb. so that the carcasses would be closely comparable.

In general, carcasses from hogs fed 27 mg. or more of methyl testosterone per day contained significantly less fat than carcasses from hogs fed no hormone (from 4% to 14% lighter bellies; from 11% to 15% lighter fat backs; from 11% to 15% lighter jowls; and from 11% to 14% less back fat). Daily methyl testosterone intake higher than 27 mg. resulted in some additional carcass alteration toward a leaner carcass, but this change was far greater between intakes of 0 and 27 mg. per day than between 27 and 62 mg. per day.

The ratio of ham to shoulder weight varied little between treatments (hams weighed approximately 1.2 times as much as the butt and picnic combined).

Loin weight varied little between lots. In the previous Purdue experiment (Beeson *et al.*, 1955), loins from testosterone-fed hogs were significantly heavier than those from the control animals.

Summary

Growing and fattening hogs were fed an average of from 0 to 62 mg. of methyl testosterone per animal daily in a free-choice protein supplement in drylot from a starting weight of 51 lb. to a final weight of from 210 to 220 lb.

A daily intake of 27 mg. or more of methyl testosterone resulted in

highly significant growth depression. However, it was in this range that decreased fat deposition was apparent as indicated by significantly less back fat thickness.

Even though free-choice consumption of protein supplement containing the graded levels of methyl testosterone was fairly constant, consumption of corn decreased as the level of methyl testosterone increased. The slower-gaining pigs consuming the higher levels of the hormone required less corn per unit of gain, but were less efficient in conversion of protein supplement, than pigs fed no hormone or than pigs fed either 9 or 17 mg. per day.

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THE EFFECT OF ORAL ADMINISTRATION OF METHYL TESTOSTERONE ON SWINE GROWTH AND DEVELOPMENT [1, 2, 3]

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RAPID growth in livestock has long been a most sought after and elusive objective of the animal husbandman. Much of the emphasis in research has been placed on breeding or feeding trials in the quest for more rapid gains. Differences in the growth rate between the sexes in many species has indicated the possible use of sex hormones to induce growth changes which may be beneficial. Desirable changes in body conformation associated with castration or sex differences might also be a result of administered sex hormones.

Experimental Procedure

Four litters of crossbred Minnesota No. 1 × (Oklahoma Line 3 Duroc × Uark Poland China) weanling pigs were used in this experiment, each providing two castrate males, two intact males, two castrate females, and two intact females. The females were castrated 10 days prior to the initiation of the experiment by means of a bilateral oophorectomy through a mid-line incision. The males were castrated a similar period preceding the start of the trial.

At the beginning of the trial, the eight pigs of each sex group were randomly allotted to four treatment groups. Levels of methyl testosterone in the feed were adjusted at periodic intervals due to increased daily feed intake to maintain the following daily intake of methyl testosterone per kilogram of body weight for the respective treatment groups: 0, 0.015, 0.15, and 1.5 mg. The water and feed was supplied *ad libitum* and the pigs were confined to concrete pens during the 76-day feeding trial. The basal ration consisted of the following feedstuffs: ground yellow corn, 72.3 lb.; solvent process soybean meal, 20.5 lb.; alfalfa meal, 5.0 lb.; dicalcium phosphate, 1.0 lb.; ground limestone, 0.5 lb.; salt, 0.5 lb.; B-vitamin supplement, 0.1 lb.; Vitamin B_{12} supple-

[1] Published with the approval of the Director of the Arkansas Agricultural Experiment Station.
[2] The methyl testosterone used in this trial was contributed by the Schering Corporation, Bloomfield, New Jersey.
[3] The authors wish to acknowledge the technical assistance of C. F. Hall, J. N. Beasley, P. M. Johnston and Chester Baugus in the conduct of this trial.
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TABLE 1. SUMMARY OF RESULTS OF FEEDING TRIAL

Milligrams of methyl testosterone fed daily per kilogram of body weight	0.0	0.015	0.15	1.5
No. of pigs per lot	8	8	8	8
Av. initial weight, lb.	52.9	53.5	53.4	49.8
Av. final weight, lb.	194.9	195.2	189.6	182.6
Av. daily gain, all pigs, lb.	1.87±.04	1.86±.04	1.80±.09	1.75±.05[a]
Castrate males	1.93	1.92	2.02	1.64
Intact males	1.97	1.84	1.95	1.82
Castrate females	1.79	1.96	1.62	1.88
Intact females	1.77	1.74	1.60	1.66
Av. daily feed per pig, lb.	6.71	6.36	6.41	6.52
Av. feed per cwt. gain, lb.	359	341	357	373

[a] Standard error of means.

ment, 0.1 lb.; Vitamin A, 272,000 I.U.; Vitamin D, 51,000 I.U. The methyl testosterone used was of U.S.P. grade. No antibiotic was used in the ration.

One castrate male in the 0 mg. treatment group did not gain in the first two-week period of the trial and was removed. Gain was computed for this animal by using the method of Snedecor (1946) for randomized block experiments.

Results and Discussion

The summary of the feeding trial results are given in table 1. There appeared to be no change in weight gain, feed consumption or feed utilization associated with the addition of methyl testosterone to the ration at these levels. The analysis of variance of weight gains (table 2)

TABLE 2. SUMMARY OF ANALYSIS OF VARIANCE OF TOTAL PIG GAINS

Source of variance	df.	Mean square
Total[a]	30	
Sex	3	388.3
Castrate males vs. intact males	1	4.0
Castrate males vs. intact females	1	812.2
Castrate males vs. castrate gilts	1	95.1
Treatments	3	459.0
0 vs. .015 level	1	0.2
0 vs. .15 level	1	110.2
0 vs. 1.5 level	1	333.1
Treatments × sex	9	185.6
Sampling	15	105.1

[a] One barrow from the group fed the basal ration failed to gain during the first two weeks of the experiment. This animal was removed from the experiment and gain computed for this pig.

TABLE 3. RESULTS OF CARCASS CUT-OUT TESTS

Milligrams of methyl testosterone fed daily per kilogram of body weight	0	.015	.15	1.5
No. animals slaughtered	5	7	6	5
Av. shrunk live weight, lb.	196.5	193.1	193.4	188.6
Dressing %, chilled carcass	69.03	68.42	68.60	69.39
Primal cuts,[a] %	60.13	60.20	60.92	61.22
Av. backfat thickness, in.	1.77	1.80	1.78	1.65
Av. carcass length, in.[b]	29.2	29.3	28.8	29.0

[a] Trimmed hams, loins, bacons, Boston butts, and picnics as percent of chilled packer-dressed carcass.

[b] Aitch bone to front of first rib.

indicated that the four treatment lots were not significantly different. There was also no statistically significant difference between the gains of castrate males compared to intact males or castrate females, however castrate males gained appreciably faster than intact females. This difference closely approached significance at the 5% level of probability.

Dressed yields of carcasses from these pigs are summarized in table 3. In general the methyl testosterone pigs yielded leaner carcasses, as evidenced by a higher yield of primal cuts, than did control pigs. There was very little difference in carcass length.

Various experiments have been conducted in which the effects of

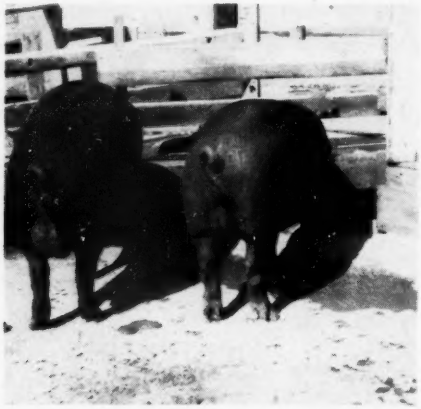

Figure 1. Boar on the left was fed control ration while boar on right was fed 1.5 mg. of testosterone.

implanting swine with testosterone have been studied. Bratzler and associates (1954) reported that boars castrated at 180 lb. yielded longer and leaner carcasses than animals castrated at 70, 100, and 140 lb. or testosterone-implanted barrows. Rate or efficiency of gain was not affected by testosterone-implantation. Sleeth *et al.* (1953) stated that

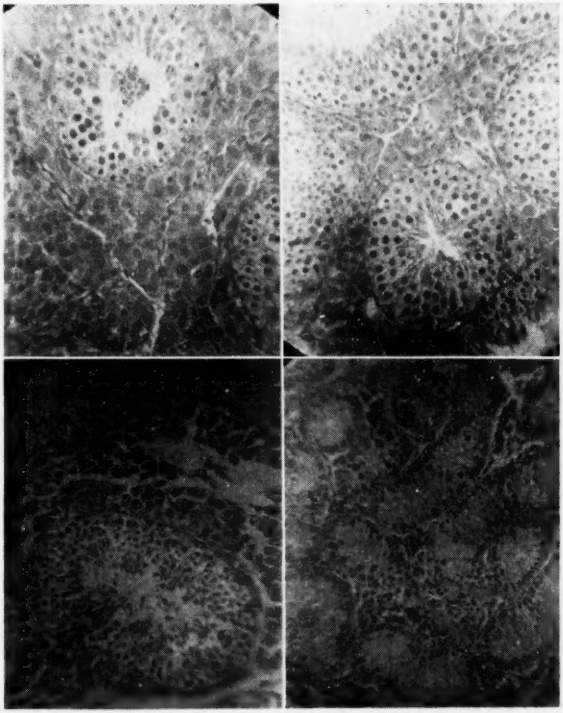

Figure 2. Cross section of peripheral testes tissue. (x 440) Upper left—control ration, upper right—.015 mg., lower left—.15 mg. and lower right 1.5 mg. testosterone per kg. body weight daily.

the intra-muscular injection of testosterone propionate semi-weekly at the rate of 0.5 mg. per kg. of body weight did not affect rate or efficiency of gain, carcass length, or backfat thickness. Woehling *et al.* (1951) reported similar findings.

As shown in figure 1, the boars fed the highest level of methyl testos-

terone had infantile testis. Testis from the two boars fed this level of hormone weighed 35 gm. each while those fed the control ration weighed 170 and 200 gm. Boars fed the other two levels of hormone yielded testis which ranged from 135 gm. to 220 gm.

Photomicrographs shown in figure 2 further verify the inhibitory effect of the high level of testosterone upon testicular development. No mature sperm was present in the seminiferous tubules of the sectional testis tissue from boars fed the highest level of testosterone. In fact the lumen of the tubules was not open, very few spermatagonia were observed, a marked hypertrophy of the Sertoli elements existed, and a subnormal amount of interstitial cells was present in the tissue.

Sectioning of testes from the two boars fed .015 mg. indicated a mild stimulation of spermatogenic activity as compared to the boars fed the control ration. However since the degree of stimulation was slight and only two animals were involved, additional work is suggested before these observations should be considered conclusive.

Tissue samples from the testes of boars fed .15 mg. indicated that they were similar in gonad development to those fed the control ration.

Interstitial cell development was more advanced in the testes of boars fed the control ration. Thus oral administration of methyl testosterone at a level of 0.15 mg. daily per kilogram of body weight inhibited interstitial development and a level of 1.5 mg. depressed mature spermatozoan production.

Summary

In a swine feeding trial four lots, consisting of 2 intact males, 2 castrate males, 2 intact females, and 2 castrate females each, were orally fed the following levels of methyl testosterone in milligrams per day per kilogram of body wight: 0, 0.015, 0.15, and 1.5. Rate of body weight gain of females was apparently slightly depressed by .15 mg. of methyl testosterone but gains of males were not affected. Pigs fed the methyl testosterone produced somewhat leaner carcasses than the control fed animals as evidenced by a higher yield of primal cuts. Spermatogenesis was markedly depressed in boars fed the highest level of hormone. Interstitial tissue development was depressed in all treated groups.

The levels of methyl testosterone fed were not effective in inducing a growth stimulus in swine, though they were effective in producing pronounced alteration of gonadal activity.

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THE EFFECT OF PROGESTERONE-ESTRADIOL IMPLANTS AND STILBESTROL FEEDING ON FEED LOT PERFORMANCE AND CARCASS CHARACTERISTICS OF STEERS [1, 6]

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THE use of hormones and hormone-like substances to stimulate the rate of gain in steers and lambs is of considerable practical significance at the present time. The work reported here was carried out to check observations from previous experimental work at this station on the implantation of steers with a 30:1 ratio of progesterone to estrogen, and to compare the effect of implantation with the effects of feeding diethylstilbestrol on slaughter and carcass characteristics and feed lot performance.

Experimental Procedure

Yearling Hereford steers from a previous feeding trial were divided into 3 lots of 14 steers each on the basis of previous gain, weight, type and grade. For a period of 140 days, starting on December 3, 1954, all lots were fed 1.5 lb. of protein supplement, and 20 lb. of corn silage per steer per day. Ground shelled corn was fed according to appetite. The protein supplement was made up of the following: soybean oil meal, .50 lb., urea, .087 lb., limestone, .20 lb., trace mineral salt .05 lb., and ground shelled corn, .663 lb.

Treatment began on January 28, 1955, as follows: Lot I, control; Lot II, fed diethylstilbestrol, 10 mg. per steer per day; Lot III, implanted subcutaneously, medial to the maxilla, with 10 pellets containing a total of 1.5 gm. progesterone and 50 mg. estradiol. This location for inserting pellets was chosen primarily because no meat

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[5] Journal Article No. 1895 from the Michigan Agricultural Experiment Station.
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from this area is used for human consumption. Implantation at this site required less time and made the task relatively simple as compared to implanting in the neck. No complications resulted from the operation. A short circuit in one of the electric water heaters caused two lots of steers to refuse feed on the treatment weigh day. Therefore, weights of the previous regular weigh day (January 14) were used in calculation of feedlot performance.

TABLE 1. FEED LOT PERFORMANCE OF EXPERIMENTAL STEERS

	Control	Stilbestrol fed	Implanted	LSD[a] (1%)
	lb.	lb.	lb.	
Initial av. wt. (12/4/54) (beginning of trial)	808	805	803	
Initial av. treatment wt. (1/14/55)	903	899	896	
Final av. wt.	1122	1158	1192	
Av. pre-treatment daily gain/steer	2.1	2.2	2.1	
Av. daily treatment gain/steer	2.30	2.64	3.03	.31
Feed consumed/100 lb. gain:				
Silage	865	754	658	
Corn	643	579	529	
Supplement	65	57	50	

[a] LSD=Least significant difference.

All cattle were slaughtered on April 25th at Detroit, Michigan. After a 48-hour chill, ribbed carcasses were graded to the nearest one third grade by a U.S.D.A. grader.

Wholesale 7-rib cuts were removed according to the method of Hankins (1946) for estimation of separable carcass fat, bone, and lean. Twelfth rib cross sections were traced and the *Longissimus dorsi* area determined by means of a compensating polar planimeter. Fat thickness at the 12th rib was measured. Sample steaks from the 12th rib area were cooked by the deep fat method; cooking shrink and Warner-Bratzler shear readings were obtained. Samples were prepared for chemical analysis from the 9–10–11 rib for both ether extract and moisture from (1) *Longissimus dorsi* (separable), and (2) combined fat and lean (separable) other than *Longissimus dorsi*. Moisture was determined for samples of: (1) kidney fat; (2) external fat. Ether ex-

tract and moisture determinations were made according to modifications of the A.O.A.C. methods (Benne, 1955).

The thyroid glands, adrenal glands, and urogenital tracts from the urinary bladder to a point beyond the bulbourethral glands were removed from four animals in each lot immediately after slaughter for gross and microscopic examinations. The tissues were fixed in 10% neutral formol-saline solution, embedded in paraffin, sectioned and stained with hematoxylin and eosin.

Results and Discussion

Feed Lot Performance

The implanted steers made an average daily gain of 3.03 lb. (table 1) compared to 2.64 lb. and 2.30 lb. for stilbestrol and control steers, respectively. The gains of both the implanted and stilbestrol-fed steers were significantly greater than the controls at the 1% level. In addition, the rate of gain of implanted cattle was significantly greater at the 1% level than of stilbestrol-fed cattle. Implantation with 1.5 gm. of progesterone and 50 mg. of estradiol (30:1 ratio) resulted in a 31.7% increase in rate of gain over controls and a 14.8% increase in rate of gain over the stilbestrol fed cattle. The stilbestrol-fed cattle showed a 14.8% increase in rate of gain over controls. These results are similar to those obtained by Henneman *et al.* (1953) who observed increased rate of gain in lambs on a similar combination hormone implant when compared with controls.

At the end of the treatment period, the implanted steers were eating an average of 17.0 lb. of corn per day as compared to 15.5 lb. and 14.0 lb., respectively, for the stilbestrol-fed and control lots. Corn consumption for the entire treatment period averaged 16.0 lb. per day for implanted cattle, 15.3 lb. for stilbestrol-fed, and 14.5 lb. for controls. The implanted steers showed a marked increase in appetite one week after implantation, which was maintained for the duration of the feeding period. Increased gain was first noted 30 days after treatment. Stilbestrol-fed cattle also showed an appetite stimulation but this did not occur until approximately 30 days after stilbestrol feeding had started. Similarly, stimulation of gain was not in evidence in the stilbestrol-fed lot until 60 days after treatment. This differs from the results of Perry *et al.* (1955) who found that the largest percent increase in gain with 870-lb. steers occurred during the first 28 days of stilbestrol feeding. It is interesting to note that the faster gains reported by these workers

were made without an increase in feed consumption, thus indicating an increased efficiency in utilization of feed consumed. They suggested that improvement in feed efficiency may have been due to increased cellulose and nitrogen utilization. However, Richardson *et al.* (1955) noted that there was a significant lowering of digestibility when 10 mg. stilbestrol was fed daily to 450 lb. steer calves, although there were increased gains.

Slaughter Performance

The differences in dressing percentages as shown in table 2 are not statistically significant. Bell *et al.* (1955) found that stilbestrol implants and combination stilbestrol-progesterone implants caused

TABLE 2. SLAUGHTER DATA

	Control	Stilbestrol fed	Implanted
	%	%	%
Cold dressing percent	61.9	62.0	62.6
Cooler shrink	1.51	1.41	1.27
Stomach fill (% sl. wt.)	3.4	3.2	3.4
Heart (% hot carcass wt.)	.65	.67	.70
Liver (% hot carcass wt.)	16.0	16.5	16.3
Spleen (% hot carcass wt.)	.26	.26	.26
Hide (% slaughter wt.)	8.0	8.2	7.9

lowering of dressing percentage in lambs. Wilkinson *et al.* (1955) also lowered dressing percentage significantly in lambs by implanting with diethylstilbestrol and feeding to yield the same carcass weight. Cooler shrink (hot to cold carcass) showed no significant difference between lots. These results are similar to those of Bell *et al.* (1955) with lambs. The percentages of the hot carcass represented in the spleen, heart, and liver showed little difference. Although results with lambs have shown heavier pelts (Bell *et al.*, 1955; Wilkinson *et al.*, 1955), there were no significant differences in hide weights in this trial.

Carcass Data

Differences in average carcass grade between lots as shown in table 3 were not significant. There was considerable variation in carcass grade in each lot as shown in table 3. It should be noted that carcasses were graded ribbed, with marbling, texture, and firmness of the lean considered in designation of grade. Carcasses from the implanted cattle

and from the stilbestrol fed cattle had a significantly greater spread between the posterior end of the aitch bone and sacral vertebrae than controls. This increase in pelvic spread is suggestive of elevation of

TABLE 3. PHYSICAL AND CHEMICAL COMPOSITION AND GRADE OF CARCASSES

	Control	Stilbestrol fed	Implanted	LSD 5%
USDA Grade				
Choice-high	1	3	0	
Choice-average	1	3	3	
Choice-low	7	5	3	
Good-high	3	3	7	
Good-average	2	0	1	
Good-low	0	0	0	
Av. coded value[a]	6.3	5.6	6.4	
Physical carcass composition[b]	%	%	%	%
Carcass lean	53.3	53.4	56.4	2.26
Carcass fat	34.7	34.2	31.3	2.77
Carcass bone	13.2	13.5	13.4	
Longissimus dorsi area (sq. in.)	9.79	9.90	10.52	
Fat thickness (12th rib), in.	.92	.96	.77	
Chemical composition	%	%	%	
External fat, % H_2O	7.94	9.15	7.89	
Internal fat, % H_2O	3.50	3.62	3.70	
Longissimus dorsi % H_2O	71.65	71.05	71.78	
ether extract	5.68	6.65	5.11	
Combined fat and lean (excl. *L. dorsi*) % H_2O	34.37	35.63	37.00	
Combined fat and lean (excl. *L. dorsi*) % ether extract	54.93	53.31	51.35	
Entire 9–11 rib cut % H_2O	41.5	42.1	44.1	
Entire 9–11 rib cut % ether extract	45.5	44.8	41.9	
Cooking shrink	19.3	19.3	18.9	
Warner-Bratzler shear readings, lb.	6.7	6.7	5.9	

[a] Based on numerical range of 1 (Prime—high) to 9 (Good—low).
[b] As estimated from 9–10–11 rib cut (Hankins, 1946).

the tail head, a characteristic which has been observed in other experiments with estrogenic substances in cattle feeding.

The physical carcass composition as estimated by the 9–10–11 rib cut showed that the implanted lot had a significantly higher proportion of lean and lower proportion of fat than carcasses from either stilbes-

trol-fed or control lots. As the percent bone remained relatively constant, an inverse relationship between percent fat and percent lean was to be expected. There were no differences in physical composition between carcasses from the control and stilbestrol-fed lots. Thus, it appears that implantation resulted in an increase in muscle mass. Although differences in fat thickness at the 12th rib were not significant, the tendency toward less external fat thickness in implanted carcasses is in agreement with the smaller proportion of separable fat in the 9–10–11 rib section as determined by physical separation. This is in agreement with results of Clegg *et al.* (1954) who reported that the amount of both internal and external fat deposition was considerably reduced in steers implanted with 60 mg. of stilbestrol. These workers also found a doubled nitrogen storage, probably in the form of protein.

By applying the percentages of moisture and fat as determined in chemical analysis of the separable rib constituents, it was possible to calculate the theoretical amount of water and ether extract in the 9–10–11 rib cut. However, no corrections were made for either moisture or fat content of the bone. While differences between lots in percentage of calculated water and ether extract in the 9–10–11 rib cut were not significant, they paralleled indications of slightly decreased fatness in the implanted cattle. Since there was little difference between lots in moisture of the external carcass fat, it is postulated that the greater moisture content in the 9–10–11 rib cut of implanted carcasses was the result of a greater proportion of lean.

Cooking tests on *Longissimus dorsi* steaks one inch thick showed no significant differences in percent cooking shrink between lots with values of 19.3, 19.3, and 18.9% loss for control, stilbestrol-fed and implanted groups, respectively.

Shear readings showed no significant differences between lots, with average values of 6.7, 6.7, and 5.9 lb. obtained for control, stilbestrol fed, and implants, respectively.

Physiological Effects

Upon gross examination, the prostatic portion of the urogenital tract was definitely enlarged in steers of the stilbestrol-fed lot and enlarged still further in steers of the implanted lot. Figure 1 illustrates grossly the effect of both progesterone-estradiol implants and oral stilbestrol on the size of the bulbourethral, seminal vesicle and prostatic portions of the urogenital tract.

Microscopic examination of sections taken through the prostatic

region of the urethra showed considerable enlargement of the pars disseminata of the prostate gland and also of the urethral muscles (figure 2). The stratum cavernosum of the urethra showed some hyperplasia. The epithelial layers adjacent to the lumen were flattened and there appeared to be no restriction in size of the lumen. The prostatic glands were hyperplastic and showed some evidence of secretory activity. Slightly more glandular development occurred in the group receiving the combination treatment with progesterone-estradiol than in those

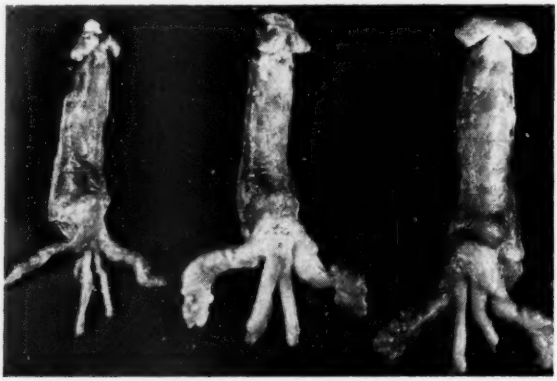

Figure 1. Gross dissection of accessory sex glands from control and experimental steers: Left, control; center, oral stilbestrol; right, progesterone-estradiol implant. In each case the bulbourethral glands are seen at the top, prostrate region in the center, and seminal vesicles at the bottom of the photograph.

receiving stilbestrol only. There was no evidence of desquamation or keratinization of epithelium and no evidence of carcinogenesis in any of the tissues examined. The bulbourethral glands from both groups also showed some evidence of secretory activity.

The enlargement of the accessory sex glands in the steers receiving steroid hormones is sufficiently noticeable that it could possibly serve as an indication of this type of hormone administration. It indicates, further, that oral stilbestrol is absorbed from the digestive tract and produces a systemic effect. This apparently anomalous effect of female sex hormones on male sex accessories was not unexpected because it has been observed previously in several other species.

Microscopically, all tissues from the control group appeared normal. The adrenal glands in both hormone treated groups also appeared

normal. No clear cut differences were observed in the thyroid histology of the treated groups as compared to the controls.

Summary

Rate of gain, efficiency of feed conversion, physiological effects and certain carcass measures are reported for three lots of steers treated as follows: Lot I, control; Lot II, fed diethylstilbestrol (10 mg. per head daily); Lot III, implanted with combination progesterone-estradiol pellets (1.5 gm. progesterone and 50 mg. estradiol).

Implanted steers had a significantly greater daily rate of gain than either stilbestrol-fed cattle or controls. Stilbestrol-fed steers had a significantly higher daily rate of gain than the controls. Average daily gains were 2.30, 2.64, and 3.03 lb., respectively, for the control, stilbestrol-fed and implanted steers. Implanted cattle ate an average of 16.0 lb. of corn per day, stilbestrol-fed steers 15.3 lb. and control steers 14.8 lb., indicating an increased appetite from hormone stimulation.

There were no significant differences in dressing percentage, cooler shrink, heart, liver, spleen or hide. There were no significant differences in carcass grade. As estimated by the 9–10–11 rib cut (Hankins, 1946), carcasses from implanted steers had a significantly greater proportion

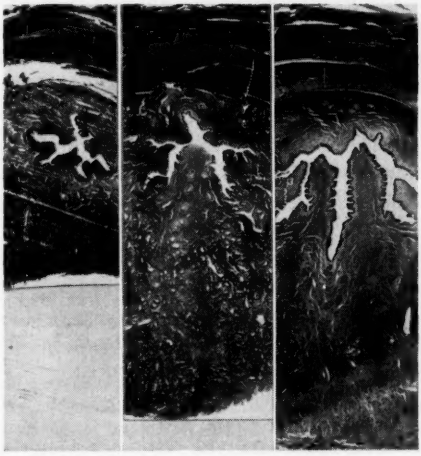

Figure 2. Sections through the prostatic portion of the urethra of steers from 3 different groups: Left, control; center, oral-stilbestrol; right, progesterone-estradiol implant (X 4.5).

of separable lean, and significantly lower proportion of separable fat than the carcasses for either stilbestrol-fed or control groups.

Moisture of external fat, internal fat, *Longissimus dorsi,* and combined separable fat and lean was not significantly different between groups. No significant differences were found in percentage of ether extract of *Longissimus dorsi,* or of combined separable fat and lean.

There was no difference in cooking shrink or in Warner-Bratzler shear readings.

Adrenal glands appeared normal in all groups. Hormone treatment either by implantation or feeding resulted in an increased diameter of the prostatic portion of the urogenital tract and an increase in size of the bulbourethral glands and seminal vesicles, indicating physiological activity due to both hormone treatments. There was some evidence of secretory activity in the prostrate and bulbourethral glands of treated steers. There was no evidence of desquamation or keratinization of epithelium and no evidence of carcinogenesis in any tissues examined.

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LIVE HOG PROBES AT VARIOUS SITES, WEIGHTS, AND AGES AS INDICATORS OF CARCASS MERIT [1]

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EFFORTS to improve carcass value in hogs by genetic means have been handicapped for lack of a rapid and accurate method of measuring carcass value in prospective breeding animals. Visual estimates and linear body measurements are not sufficiently accurate to warrant their general use (Hetzer *et al.*, 1950; Bratzler *et al.*, 1953). Direct carcass measurements which require slaughter of the animals can provide information for selection between families and sires, but these are likely to lengthen generation interval and are too laborious to apply on a large scale.

Hazel and Kline (1952) developed a method of measuring the backfat thickness on the live hog. The measurements cause little discomfort to the hogs, the data is easily obtainable, and the information is available immediately. From correlation studies with lean cuts it appeared that the live hog probe measurements were more accurate indicators of leanness and carcass value than the average of the carcass backfat measurements. In an attempt to refine and improve the accuracy of their technique, Hazel and Kline (1953) reported on the accuracy of probes made at eight sites; of these the ones behind the shoulder, over the loin, and on top of the ham were found to be the most useful.

The purpose of obtaining the probe measurements described in this paper was to determine what combination of sites have the greatest value in predicting carcass quality and to compare the accuracy of the probe measurements at various weights and ages.

Materials and Methods

Probe measurements in this study were taken behind the shoulder and at the middle of the loin over the longissimus dorsi on one side of 111 pigs just prior to slaughter at about 210 lb. live weight. These pigs were of Duroc breeding and crosses of Duroc-Landrace, Duroc-Poland China,

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and Duroc-Chester White. Subsequent carcass data were obtained through the cooperation of Wilson & Co., Oklahoma City.

In addition 73 pigs were probed behind the shoulder, at the middle of the back, and the middle of the loin over the longissimus dorsi on both sides. Twelve Duroc pigs from Line OK-8, 12 Beltsville No. 1 pigs from Line OK-9 and 12 each of the reciprocal crosses between these two lines were selected to be probed at 56, 84, 112 and 140 days of age. These 48

TABLE 1. CORRELATION OF CARCASS TRAITS WITH CARCASS BACKFAT AND PROBE BACKFAT

Traits	Carcass[a] backfat	Average of[a] six probes	Average of[b] two probes
Carcass backfat		.69	.36
Percent lean cuts	—.66	—.57	—.07
Percent primal cuts	—.58	—.67	—.13
Loin lean area	—.28	—.26	
Ham specific gravity	—.30	—.36	
Carcass index	—.43	—.55	—.37
Carcass length	—.11	—.33	—.05

[a] Intra-breed and intra-sex correlation with 68 degrees of freedom; carcasses cut in College Meats Laboratory.

[b] Intra-breed and intra-sex correlation with 104 degrees of freedom; carcasses cut by Wilson & Co., Oklahoma City, Oklahoma.

pigs were probed behind the shoulder, at the middle of the back, and at the middle of the loin alternating right and left sides of the pig with various ages. At market weight the three measurements were taken on both sides. Carcasses were cut in the college Meats Laboratory according to the description given by Whiteman *et al.* (1951).

Results and Discussion

Accuracy of Probes at Slaughter Weight

In the first group of 111 pigs backfat thickness was measured on the carcass at the seventh rib only and was correlated .36 with the average probes behind the shoulder and over the loin of the live hog before slaughter. In the second group of 73 pigs probes were taken on both sides behind the shoulder, over the loin and over the back and the average was correlated .69 with the average carcass backfat thickness. A comparison of the predictive value of the two methods of measuring backfat thickness was made by correlating the two measurements with a number of carcass traits as summarized in table 1. A striking difference was noted between correlations of carcass traits with the average of two

probes taken the first season and the correlations of carcass traits with the average of six probes taken the following season. The experience gained by the author in probing over 100 pigs the first season unquestionably influenced the accuracy of the measurements taken in the following season, and furthermore averaging six probes would tend to reduce measurement errors more than averaging two probes.

The correlations between the average of six probes with percent primal cuts, carcass index, ham specific gravity, and carcass length were larger than those correlations between carcass backfat and the same carcass traits. Hetzer *et al.* (1956) reported an intra-sex-and-line correla-

TABLE 2. MEAN AND VARIABILITY OF PROBE BACKFAT AND CORRELATIONS WITH CARCASS BACKFAT AT DIFFERENT AGES

Probe measurements in inches[a]	Correlations[b]		Mean probe	Standard deviation
	Total	Intra-		
S-B-L at 56 days (one side)	.16	.01	.23	.08
S-B-L at 84 days (one side)	.29	.11	.49	.16
S-B-L at 112 days (one side)	.63	.30	1.07	.21
S-B-L at 140 days (one side)	.83	.51	1.49	.32
S-B-L at final age (one side)	.86	.65	1.65	.26
S-B-L at final age (both sides)	.85	.68	1.64	.25
S-L at final age (one side)	.84	.67	1.70	.25
S-L at final age (both sides)	.86	.69	1.69	.24
S-B at final age (both sides)	.81	.59	1.69	.28
Carcass backfat at 210 lb.			1.60	.25

[a] S-probe behind the shoulder; B-probe over the back; L-probe over the loin.
[b] Total correlation with 71 degrees freedom, intra-breed and sex correlation with 68 degrees of freedom.

tion involving live hog measurements at 225 lb. of —.33 for carcass backfat and —.42 for probe backfat with percentage lean in the ham. The correlations of —.30 for carcass backfat and —.36 for probe backfat with ham specific gravity given in table 1 are in remarkable agreement.

The intra-breed and sex correlation of .69 between the average backfat thickness on the carcass and the average of six probes is in essential agreement with the correlation of .81 reported by Hazel and Kline (1952) between average carcass backfat and four probes, and the correlation of .72 reported by Hetzer *et al.* (1956) between average carcass backfat and three probes.

Predictive Value of Probes at Lighter Weights

The accuracy of selecting replacement stock on the basis of probe backfat may be influenced by the age and weight at which the probes

are made. The information from the 48 pigs probed at 56, 84, 112, and 140 days of age and at slaughter weight is pertinent (table 2). As might be expected probing at 56 and 84 days had little value in predicting the carcass backfat at slaughter weight. Fat is the latest developing of the major body tissues and at stages of growth up to about 112 days the potential variation in fat deposition between individuals has not been expressed.

The correlations between thickness of backfat on the carcass and live hog measurements taken at various ages were all positive and showed a definite upward trend with increasing age. The correlation values of .38, .58, .55 and .72 between the same measurements taken at 150, 175,

TABLE 3. AVERAGE WEIGHT AND AVERAGE BACKFAT PROBE AT DIFFERENT AGES OF LINES 8, 9 AND THEIR RECIPROCAL CROSSES

Age in days	Average weight	Probe backfat		
		OK 8	Crossbreds	OK 9
	lb.			
56	39	.28	.21	.22
84	74	.54	.47	.49
112	128	1.17	1.06	1.04[a]
140	185	1.75	1.48	1.34[b]
155–161	211	1.87	1.60	1.45

[a] This measurement is interpolated for 128-lb. weight from measurements at 112 and 140 days. The actual probe at 112 days was .97 in. at 117 lb.

[b] This measurement is interpolated for 185 lb. weight from measurements at 140 and 161 days. The actual probe at 140 days was 1.29 in. at 165 lb.

200, and 225 lb. live weight respectively, taken by Hetzer *et al.* (1956) show a similar trend. For reference the average weights for the various ages reported in this study are given in table 3. There was no difference between the total correlation of 140-day probe and probe at slaughter weight with carcass backfat but when the variations due to breed and sex were removed the correlation increased from .51 to .68 when measurements were taken at 140-day weight and final-slaughter weight respectively. Thus when selecting gilts on the basis of backfat thickness greater accuracy can be expected if they are not probed before they reach about 200 lb.

The correlation between the weight and probe measured on the same day increased with age so that at 140 days about 41% of the variation in probe measurements were associated with variation in weight. As a result of the difference in growth rate between the two breeds it was

noted that the OK 8 pigs were 20 lb. heavier than the OK 9 pigs in average live weight at 140 days of age. The magnitude of the variability in live weight at this age partially explains the large standard deviation of 140-day backfat probe. McMeekan (1940) demonstrated that there is more variation in later developing tissues, fat, than in earlier developing tissues, skeletal and bone.

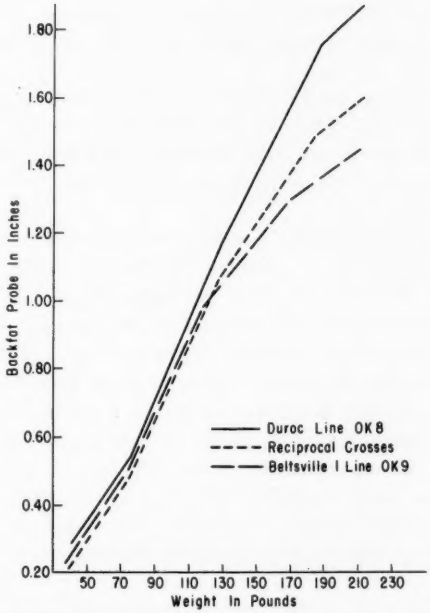

Figure 1. Relationship between weight and probe backfat thickness.

Patterns of Growth and Backfat Deposition

Table 3 gives the mean backfat thickness as measured by the probe at monthly intervals from weaning to the time the pigs attained a slaughter weight of about 210 lb. Figure 1 shows the pattern of fat deposition by the two lines and the crossbreds. The faster-growing, fatter OK 8 Durocs had about .06 in. more fat at initial weight and maintained that difference to 84 days. From 112 to 140 days the Durocs seemed to deposit fat more rapidly than the OK 9 Beltsville No. 1's or

the crossbreds. Some of the measurements on the Beltsville No. 1's were interpolated to a live weight basis comparable to the Durocs and crossbreds. The Durocs deposited an average of .58 in. of backfat as compared with .42 in. for the crossbreds and .30 in. for the Beltsville No. 1's in the period from about 128 lb. to 185 lb. After 140 days the rate of fat deposition appeared to level off and was quite similar for all breeds. Presumably the arrested rate of deposition could be partially accounted for in that the probe measures only backfat thickness, and does not take into account the larger surface on which the subcutaneous fat is being deposited by virtue of the pigs' growth in length and width.

Apart from the apparent less backfat of the crossbreds at 56 days and maintaining that difference to 84 days, the crossbreds were intermediate between the parent lines in backfat thickness. This would suggest that the genes influencing backfat deposition act largely in an additive manner.

The accuracy with which differences between individuals in a group can be determined will be influenced by the live weight range of the individuals at the time the probe measurements are made. From the standpoint of labor and management, probing animals within a very narrow weight range is not feasible. Taylor and Hazel (1956) found the growth curves of pigs weighed at 10-day intervals from 134 to 174 days of age to be essentially linear for the period. Plotting backfat probe in inches against weight in pounds (figure 1) suggests that the relationship between them is approximately linear. Selection of pigs to produce leaner carcasses using the backfat probe as a tool would appear to be particularly valuable if the measurements were taken at about 180 lb. live weight when differences in potential backfat thickness had been expressed.

Summary

The measurement of backfat thickness on the pigs at a live weight of about 210 lb. by an average of six probes was more highly correlated with percent primal cuts, carcass index, and ham specific gravity than was backfat thickness measured on the carcass.

The correlations between the thickness of backfat on the carcass and the live hog measurements taken at various ages were all positive and showed a definite upward trend with increasing age. The predictive value of probes taken prior to 112 days of age was very low. The intra-

breed and intra-sex correlation of average probe at slaughter weight with average carcass backfat was 0.69.

Patterns of fat deposition as measured by probe backfat at different ages are shown for two lines and their reciprocal crosses.

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STUDIES ON PARAKERATOSIS IN SWINE

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THE severe skin affliction or dermatitis of swine which was first characterized and named "parakeratosis" by Kernkamp and Ferrin (1953) is believed to have affected swine at Beltsville for many years. A mange-like condition which failed to respond to conventional treatments for sarcoptic mange occurred several times during the period from 1935 to 1939. The report by Hogan and Johnson (1941) has appeared to be the first accurate clinical description of parakeratosis in the literature. Since that time many investigators have reported the occurrence of a condition with similar or identical symptoms.

In addition to outbreaks in college swine herds at Cornell, Florida, Illinois, Iowa State, Michigan State, Minnesota, Nebraska, Purdue, and Wisconsin, and in commercial herds in various parts of this country, a similar condition has been reported in England by Thomas and Eden (1954). Within the past three years, scientists from Denmark and Sweden visiting at Beltsville have stated that swine in their countries have also been affected by parakeratosis.

Parakeratosis has occurred at Beltsville on a wide variety of diets and with a wide range in severity of symptoms, which include skin lesions, diarrhea, anorexia, and retardation of growth, but has very rarely resulted in mortality. The condition has appeared most often in pigs from 10 to 16 weeks of age and has been almost completely limited to fall-winter feeding trials.

Although pigs with severe symptoms of parakeratosis have had significantly lower levels of serum vitamin A than normal animals, oral therapy with massive doses of vitamin A acetate has been of no apparent benefit to improvement either of disease conditions or of serum vitamin A level. Whether avitaminosis A was due to depressed food consumption or failure to absorb vitamin A from the digestive tract was not determined. Attempts to alter the course of parakeratosis by changes in quality of dietary protein were also ineffective.

The association between high calcium content in swine diets and intensified symptoms of parakeratosis was reported by Ellis (1953). Results of this experiment, which was designed to investigate a "rickets-

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like" lameness occurring on cottonseed meal diets, indicated that high calcium content was a major factor in increasing incidence and severity of parakeratosis but did not rule out the possibility that an imbalance of the calcium-phosphorus ratio might also be implicated. Since the diets used in this experiment were supplemented with cobalt, zinc, magnesium, manganese, copper, and iron (a re-examination of the diets showed that 6 p.p.m. of supplementary zinc were supplied by the basal mineral mixture used) the report by Raper and Curtin (1953) on curative and protective properties of supplemental cobalt (1.1 p.p.m.) and zinc (4.0 p.p.m.) was first received with skepticism. The skepticism was short-lived for evidence in support of Raper and Curtin's results was obtained almost immediately.

In a study of cottonseed meal toxicity, the trace minerals had been omitted in 5 of the 6 diets. No symptom of parakeratosis appeared in the pigs receiving trace minerals (including 12.0 p.p.m. zinc) but a very high incidence (80 to 100%) was noted on all 5 diets from which trace minerals had been omitted. Additional evidence that parakeratosis can be prevented or cured by the addition of various zinc compounds and that high levels of calcium tend to aggravate the condition has been presented by Tucker and Salmon (1955), Hoekstra (1955), and Luecke *et al.* (1956).

An opportunity for a practical demonstration of the efficiency of zinc therapy was presented by an outbreak of parakeratosis in some 300 pigs on record-of-performance tests at Beltsville about two weeks preceding the experiment herein reported. Approximately one-third of the animals fell into each of three categories: mild to acute symptoms; trace to questionable; and not obviously affected. The addition of 48 p.p.m. of zinc either as zinc oxide or zinc sulphate, to the regular swine diet was effective in quickly restoring normal growth rate and in eventually restoring normal skin condition. The regular diet was found to have contained 0.8% of calcium and 30 p.p.m. of zinc.

The experiment which is reported here was undertaken with two main objectives: (1) to clarify the interrelation of zinc and calcium levels in the diet as it has affected the incidence and severity of parakeratosis occurring in swine at Beltsville, and (2) to initiate an investigation of the mechanisms involved in the production of this condition.

Experimental Procedure

On December 1, 1955, 6 sets of 8 littermates each (48 weanling pigs) were allotted in a randomized block design to 8 test diets which were

TABLE 1. COMPOSITION OF DIETS AND TREATMENT VARIABLES

Treatment group	1	2	3	4	5	6	7	8
Ingredients	%							
Cottonseed meal (degossypolized)	25.0	—Same as No. 1—	25.0	—Same as No. 3—	—Same as No. 3—	25.0	—Same as No. 6—	—Same as No. 6—
Yellow corn meal	68.0		67.5			66.3		
Alfalfa meal (dehydrated)	5.0		5.0			5.0		
Aurofac [a]	.4		.4			.4		
Vitamin D (350 I.U./lb. of diet)	+		+			+		
Bonemeal (steamed)	—		—			1.8		
Ground limestone	.1		.6			—		
Mineral mixture [b]	1.5		1.5			1.5		
Zinc oxide	—	0.0015	—	0.0015	0.006	—	0.0015	0.006
Treatment variables								
Total zinc (p.p.m.)	32	44	32	44	80	32	44	80
Total calcium (% of diet)	0.48	0.48	0.67	0.67	0.67	1.03	1.03	1.03

Crude protein content of all diets 18%.

[a] 1.8 gm. chlortetracycline hydrochloride and 1.8 mg. vitamin B_{12} per pound.

[b] Mineral mixture—Equal parts iodized salt, steamed bone meal, and ground lime stone, plus iron, copper, cobalt, and magnesium.

self-fed throughout the experiment. These pigs were crossbreds of predominantly Landrace-Poland China breeding and were from 58 to 67 days old when placed on test. Details of diet composition and treatment variable appear in table 1. The basal diets were similar to those which produced parakeratosis in 1954–55 feeding trials; they assayed 32 p.p.m. of zinc and 18% crude protein.

Results and Discussion

The first symptoms of parakeratosis appeared promptly in a regular and characteristic sequence. After 12 days on test the pigs in lot 6, which received the high (1.03%) calcium diet without supplemental zinc, exhibited a slight diarrhea and a slight decrease in appetite and rate of gain. Definite skin lesions indicative of parakeratosis were observed from 2 to 10 days later and the diarrhea, anorexia, and retardation of growth became more pronounced. In the other lots the onset, incidence, and severity of parakeratosis appeared to be determined by the zinc and calcium contents of the diets. Increases in these two minerals produced opposing tendencies: Symptoms, including depression of growth, were intensified at the two lower zinc levels with increases in the level of calcium in the diet, but were improved or eliminated as the zinc level was increased.

Figure 1 presents a graphic summary of the effects of the various treatments on the average weight gain for the first 42 days and includes a summary of the incidence of dermatitis for this period. Figure 2 compares littermates (each representative of its respective group) from 4 dietary treatments. The pair of pigs in the upper picture received the highest level (1.03%) of dietary calcium and those in the lower picture the medium level (0.67%), while in each pair the smaller parakeratotic pig received the lowest level (32 p.p.m.) of dietary zinc and the large, thrifty-looking animal received the highest level (80 p.p.m.) of zinc in the diet.

At 42 days certain reversals were made in dietary treatment (figure 1) for the purpose of studying the curative properties of zinc added to diets 3 and 6 and the possible storage or carryover of protective effect supplied by the high level (80 p.p.m.) of dietary zinc in diets 5 and 8. Three of the 6 litters used on test were randomly selected for these treatment reversals. The three pigs from these litters which had received the medium level (0.67%) of calcium (lot 3) without supplemental zinc (32 p.p.m.) were moved to the lot (5) receiving the same calcium with 80 p.p.m. of zinc, while their littermates in lot 5 (0.67%

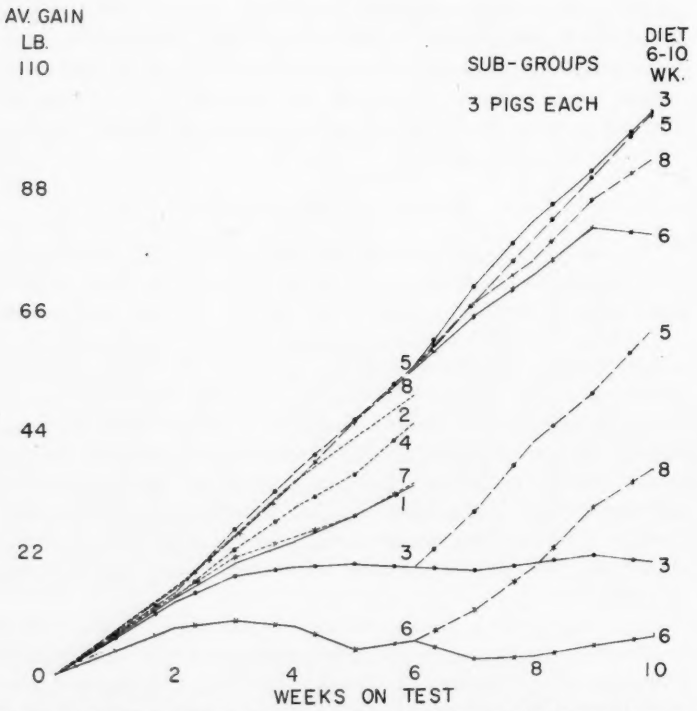

Figure 1. Effects of dietary levels of zinc and calcium on incidence of parakeratosis and on average weight gain of pigs...

Legend			Parakeratosis (at 6 weeks)		
Treatment	Zinc (p.p.m.)	Calcium (%)	Pos. (+)	?	Neg. (−)
1	32	0.48	3	0	3
2	44	0.48	1	0	5
3	32	0.67	6	0	0
4	44	0.67	1	1	4
5	80	0.67	0	0	6
6	32	1.03	6	0	0
7	44	1.03	3	1	2
8	80	1.03	0	0	6

calcium and 80 p.p.m. zinc) were shifted to group 3 (0.67% calcium and 32 p.p.m. zinc). Pigs from these same 3 litters in group 6 (1.03% calcium and 32 p.p.m. zinc) and group 8 (1.03% calcium and 32 p.p.m. zinc) were reversed in a similar manner.

The reversal of treatments effectively demonstrated the rapid therapeutic effectiveness of dietary zinc. Improved appetite, drying of skin lesions and a decrease in diarrhea were noted within the first week, followed by a gradual loosening and shedding of scurf and scabs accumulated during the active stage of parakeratosis. The effect on average weight gain was immediate and marked. (Figure 1). During 42 days on the basal low zinc (32 p.p.m.) diet, average daily gains of individual pigs ranged from —0.11 to +0.25 lb. at the 1.03% calcium level

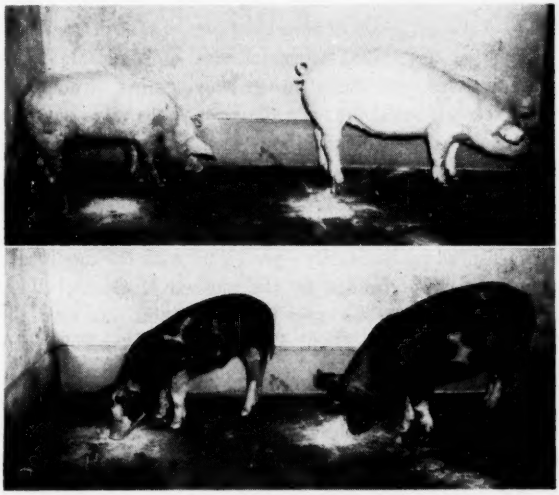

Figure 2. The pigs in the upper picture received 1.03% of calcium, those below 0.67%. The smaller pig of each pair received 32 p.p.m. of zinc and the larger one 80 p.p.m.

and from +0.25 to +0.96 lb. at the 0.67% calcium level. For 28 days following reversal to the high-zinc (80 p.p.m.) diets, the same pigs registered average daily gains from +0.79 to +1.30 lb. at the 1.03% calcium level and from +1.37 to +1.81 lb. at the 0.67% calcium level.

The shift from 80 to 32 p.p.m. zinc in the diets gave somewhat slower and less dramatic effects (figure 1), but the first definite lesions of parakeratosis were noted 21 days after the change in diet. At the termination of the test, 28 days after diet reversal, parakeratosis had become established in 1 of 3 pigs on the 0.67% calcium level and 2 of 3 pigs on the 1.03% calcium level, though not in as severe form as had occurred in the first stage of the tests. All animals were slaughtered and examined

by the staff veterinarian. Samples of skin lesions and internal organs were obtained for later histological study.

Studies on Blood Chemistry

After 35 days of test feeding, when symptoms of parakeratosis had become well established, blood samples were obtained from two animals on each treatment. The samples from these two series of littermates were used for determinations of hemoglobin, serum inorganic phosphorus, and serum nitrogen fractions (i.e. total, non-protein, albumin, and globulin nitrogen). In a second series of blood samples obtained from all animals after 70 days on test diets, determinations of sugar and of alkaline phosphatase activity were added to the previous list of analyses. However, in this second series, nitrogen determinations were omitted except in the instances of a few advanced and persistent cases of parakeratosis.

Analytical Methods Hemoglobin was determined as acid hematin using a photoelectric colorimeter. Inorganic phosphorus was determined by the method described by Gomori (1942). Alkaline phosphatase activity was measured by Bodansky's procedure with the modification that all phosphorus was determined by the method of Gomori. The Clark-Collip modification of the Kramer-Tisdall method was used for serum calcium and the method of Godden (1937) for magnesium determinations. Sugar was determined by a method based on the principle of Folin and Malmros described by Hawk *et al.* (1951). All nitrogen determinations were made by the micro-Kjeldahl technic. Fifteen percent trichloroacetic acid was used for precipitation of total protein, and 26% Na_2SO_4 for precipitation of total globulin.

All blood samples were taken between 8:00 and 9:00 a.m. Since the diets were self fed, the samples did not represent fasted blood but were considered to be taken under comparable conditions of absorption in all animals.

Results. The number of animals in a given category, based on diet and stage of parakeratosis (i.e., normal, active, healing, or recovered) was too small to justify statistical treatment of the data, nor are the averages considered to be meaningful. The general trends suggested by the data are summarized briefly below. Individual data on certain factors, apparently influenced by dietary variables or development of parakeratosis (table 2) illustrate the degree of some of the differences discussed in the text. These data in table 2 are results of analyses of blood samples from three sets of littermates which had been on their respective treatments for 70 days.

Serum calcium and magnesium apparently were not appreciably affected either by the development of parakeratosis or by variations in diet. The first series (35-day samples) of analyses averaged 12.2 mg. calcium per 100 ml. of serum (range 11.3 to 13.8 mg.) and the second series (70-day samples) averaged 11.8 mg. calcium per 100 ml. of

TABLE 2. BLOOD ANALYSES

Diet no.	Zn	Ca	Litter no.	Degree of parakeratosis	Blood		Serum	
					Hb	Sugar	Inorganic P.	Phosphatase activity
	p.p.m.	%			g./100 ml.	mg./100 ml.	mg./100 ml.	units/100 ml.
1	32	0.48	1	none	13.5	60	8.7	3.2
			2	none	13.0	70	9.0	1.7
			3	none	13.1	70	9.0	3.1
3	32	0.67	1	active	12.0	33	7.0	4.3
			2	active	12.8	60	7.2	1.0
			3	active	11.2	50	5.6	.8
6	32	1.03	1	active	10.8	59	6.9	1.2
			2	active	10.8	34	6.9	.6
			3	active	11.4	46	7.6	3.9
2	44	0.48	1	none	14.0	60	8.9	3.3
			2	none	12.4	66	9.0	.4
			3	none	13.8	67	8.6	5.1
4	44	0.67	1	none	13.8	72	7.8	6.1
			2	none	13.8	61	8.5	5.9
			3	recovering	11.8	56	7.4	2.1
7	44	1.03	1	recovering	13.1	69	8.7	1.7
			2	none	13.7	66	9.9	1.5
			3	recovering	9.9		7.6	4.4
5	80	0.67	1	none	12.5	67	7.6	3.6
			2	none	12.7	67	7.8	2.3
			3	none	12.7	63	9.5	3.7
8	80	1.03	1	none	13.0	65	8.7	3.6
			2	none	13.3	64	8.4	3.1
			3	none	12.0	76	8.4	2.5

serum (range 10.9 to 13.2 mg.). Magnesium values in each series averaged 2.4 mg. per 100 ml. of serum (range 1.8 to 2.6 mg.).

Pigs with either active parakeratosis or acutely depressed growth rate were definitely, though not markedly, lower in hemoglobin than their normal litter mates. No association between hemoglobin level and diet was established.

Nearly all of the affected animals showed a marked depression of serum inorganic phosphorus.

Blood sugar tended to be lower in all animals in which parakeratosis

had become established. Low values seemed to persist even in recovering cases which were gaining weight as a rsult of zinc therapy.

Serum alkaline phosphatase activity was extremely variable in all groups receiving the two lower levels (32 or 44 p.p.m.) of zinc (range 0.4 to 6.1 Bodansky units per 100 ml. of serum) without any recognizable relation to skin condition, rate of gain, or variation in dietary calcium and phosphorus. A much narrower range (2.3 to 3.7 Bodansky units) of values was obtained from animals which had received the high (80 p.p.m.) zinc diet for the entire 70 days. Similarly, values for animals which were shifted from high zinc (80 p.p.m.) to low zinc (32 p.p.m.) diets for the last 28 days were relatively uniform. However, in this last case, phosphatase activity fell from 3.1 Bodansky units (range 2.3 to 3.7) to 1.6 (range 1.0 to 2.5 units).

Relatively slight differences in total serum protein were not correlated with parakeratosis or diet variables. However, pigs with well established cases of parakeratosis showed a marked increase in globulins and a corresponding decrease in albumin. After 35 days on test, 4 pigs with parakeratosis of 2 to 3 weeks duration showed an average albumin ratio of 0.39 (range 0.32 to 0.43), while 12 normal animals had an average ratio of 0.68 (range 0.56 to 0.81). Protein analyses after 70 days on test made on 4 pigs with parakeratosis of approximately 49 days duration gave still lower ratios ranging from 0.15 to 0.23.

Summary

The relationship between zinc and calcium contents of the diet and the incidence of both severe parakeratosis and depressed rate of growth was demonstrated in an experiment involving 8 lots of 6 pigs each. Feeding a basal diet containing 32 p.p.m. of zinc with a calcium content of 0.48% produced mild to moderate parakeratosis in 3 of 6 pigs. An increase in calcium content (0.67 or 1.03%) at the same (32 p.p.m.) zinc level produced severe parakeratosis in all pigs (2 lots of 6 each). The addition of zinc oxide to increase total zinc content of the diet to 44 p.p.m. reduced the incidence of parakeratosis from 3 of 6 to 1 of 6 animals affected at 0.48% calcium, from 6 of 6 to 2 of 6 affected at 0.67% calcium, and from 6 of 6 to 4 of 6 animals affected with 1.03% calcium in the diet. The further addition of zinc oxide to increase total zinc content to 80 p.p.m. in the diet completely prevented parakeratosis on the two levels of calcium tested (0.67 and 1.03%). Rate of gain proved to be a sensitive indicator of occurrence, severity, and

duration of parakeratosis. Depression of appetite and rate of gain were usually observed before skin lesions appeared and the first noticeable symptoms of recovery were improved appetite and dramatic increases in weight.

Pigs with acute parakeratosis showed marked improvement within the first week after changing from 32 p.p.m. of zinc in the diet to 80 p.p.m. and within 28 days were normal except that some of the scabs and encrustations had not shed completely. Definite lesions indicative of parakeratosis appeared in 3 out of 6 pigs 28 days after they were shifted from 80 p.p.m. of zinc to 32 p.p.m. of zinc in the diet.

The results indicate that, in diets for growing pigs which contain up to 1.0% calcium, the minimum zinc content for prevention of parakeratosis is between 44 p.p.m. and 80 p.p.m.

Studies on blood chemistry, while not conclusive, provide preliminary data for further study of the probable mechanisms involved in production of parakeratosis. The results suggest that parakeratosis may depress levels of hemoglobin, serum inorganic phosphorus, and blood sugar and in addition may cause a shift in albumin-globulin ratio. Pigs receiving the lower levels of zinc (32 or 44 p.p.m.) exhibited extremely variable serum alkaline phosphatase activity as compared with pigs on the high zinc diet.

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USE OF STABILIZED TALLOW IN SWINE RATIONS[1]

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HOGS have been fed 10 and 15% raw ground beef fat successfully in mixed rations (Kropf *et al.*, 1954). There were no consistent increases in weight gain, but added fat increased feed efficiency. Feeding 1 to 10% lard in place of corn in the growing and fattening ration also was without effect on growth rate (Perry *et al.*, 1953). Average daily feed consumption was lower in lots containing higher levels of lard, and less feed per 100 lb. gain was required.

Feeding of 10% beef fat or 10% brown grease (Barrick *et al.*, 1954) and 10% prime burning lard (Day *et al.*) resulted in improved rate and efficiency of gain. These latter two studies indicated an increase in backfat thickness and some tendency towards carcasses which were not so firm.

Variation in results as regards weight increase indicated a necessity for further work. Determination of the replacement value of fat and of possible effects on palatability of the pork produced was desirable.

Experimental

Three trials have been completed under dry lot conditions using 5 and 10% stabilized renderers tallow and 10% stabilized lard. The tallows were from 2 different sources, and those in trials 1 and 2 were from different batches of the same manufacturer. The grade of tallow used in trials 1 and 2 were known as "Bleachable Fancy"; that in trial 3, "Extra-Fancy". The rations are given in detail in table 1. As the weight of the animals increased the level of protein was decreased.

In the high fat rations the percentage of protein was increased to keep the calculated nutritive ratio the same as in the control ration. The ratio of alfalfa and animal protein was also increased. These changes were made in view of the experiments cited above where it was shown that average daily feed consumption was lowered on high fat rations. In trials 2 and 3 a second control ration was used which had the same calculated crude protein level as the rations containing 10% of tallow.

[1] This study was supported in part by a financial grant from the Pacific Coast Renderers Association and supplies of tallow from the Stockton Tallow Works Co., Peterson Tallow Co., Inc., and Peterson Manufacturing Co., Inc.

[2] Department of Animal Husbandry, Davis.

TABLE 1. RATIONS USED

Ration No.	1[a]			2[a]			3		4		5		6		7	
Ration variations for different weight hogs[b]	A	B	C	A	B	C	A	B	A	B	A	B	A	B	A	B
	Control			10% Tallow			Control 1		Control 2		10% Tallow		10% Lard		5% Tallow	
Ground barley	76.5	81.5	84	57.5	62.5	66	82.5	86	75.5	80	62.5	66	62.5	66	72	76
Meat and bone scraps, 50% protein	8	7	6	10	9	7	7	6	7	6	9	7	9	7	8	6.5
Alfalfa meal	5	5	5	6	6	6	5	5	5	5	6	6	6	6	5.5	5.5
Soybean meal	5	3	2	8	6	5	2.5	1	6	4	6	5	6	5	4.5	3
Cottonseed meal	5	3	2	8	6	5	2.5	1	6	4	6	5	6	5	4.5	3
Oystershell flour			.5			.5		.5		.5		.5		.5		.5
Salt	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5
Tallow				10	10	10					10	10			5	5
Lard													10	10		
Calculated crude protein, %	16.0	14.1	13.0	18.1	16.3	14.7	15.0	13.5	17.4	15.7	17.3	15.7	17.3	15.7	16.2	14.4
Calculated nutritive ratio	4.5	5.3	6.0	4.5	5.3	6.0	5.0	5.7	4.2	4.7	5.1	5.8	5.1	5.8	5.0	5.8

[a] Ration 1A, B, C supplemented with 6.5, and 2A, B, C, with 7.3 gm. of Quadrex 10 per cwt. Supplement contains 10,000 USP units Vitamin A and 1250 USP units Vitamin D per gm.

[b] 1A and 2A fed to 90 lb., 1B and 2B from 90 to 150 lb., and 1C and 2C from 150 lb. to market. 3A, 4A, 5A, 6A, 7A fed to 150 lb., and 3B, 4B, 5B, 6B, 7B from 150 lb. to market.

Small aliquots of feed were taken from each batch of feed mixed in trial 3. These aliquots for each feed were thoroughly mixed and sampled for chemical analysis. The ether extracts (dry matter basis) were 2,0, 2.0, 8.6, and 11.8% for the control 1, control 2, 5% tallow, and 10% tallow rations.

Duroc barrows and gilts were group fed in concrete pens in all 3 trials. They were self fed. In trials 2 and 3 the hogs were probed for backfat thickness in the standard manner over the first and last ribs and last lumbar vertebrae. In trial 2 probing was done with a small metal depth gauge and in trial 3 with a leanmeter.

In trial 1, loin roasts were saved for pork flavor studies [3] from 2 hogs in each lot. These were roasted at 350° F. to an internal temperature of 185° F. Trimming was all done at the time the carcasses were broken, and this was done uniformly leaving approximately ¼" of backfat. Following cooking, the meat was cut from the bone, and excess fat trimmed. Slices ¼" thick were served as warm and as soon after cutting as possible. Judges were not trained for pork flavor, but had had experience in other flavor panels.

Results and Discussion

Results are given in tables 2 and 3. Pigs raised on rations containing 10% tallow showed a greater weight increase, and these increases were statistically highly significant ($P<.01$) in trials 1 and 3 and significant in trial 2 ($P<.05$) (table 3). By least significant difference (table 2) they are all highly significant. The increase in gain on the 5% tallow ration (trial 3) was significant at the 5% level. Addition of 10% lard caused an apparent increase in gain (trial 2) which lacked statistical significance.

Backfat thickness tended to follow rate of gain, and the increase in backfat thickness on rations containing 5 and 10% tallow was highly significant ($P<.01$). The addition of 5% lard produced an increase in backfat thickness which was significant at the 5% level. In trial 2 the backfat thickness difference between the two controls was significant at the 5% level, but in trial 2 the direction of the difference was reversed and without statistical significance.

Differences in backfat thickness were not great, and there is no reason to believe that they are greater than would be accounted for by the increased body weight.

[3] The author would like to express his appreciation to the Department of Food Technology and Marion Simone in particular for supervising and conducting the flavor studies.

TABLE 2. SUMMARY OF RESULTS

Trial	Lot	Ration	No. pigs	Days	Av. initial wt.	Av. total gain	Av. daily gain	Av. daily feed	Feed per cwt. gain	Calculated TDN per cwt. gain	Av. backfat thickness
					lb.	lb.	lb.	lb.	lb.	lb.	in.
	1	1	10	82	61.2	130.9	1.60	4.63	290	220	
	2	1[a]	10	82	59.6	132.1	1.61	4.64	288	219	
1											
	3	2	10	82	60.8	161.6**[b]	1.97	6.37	323	278	
	4	2[a]	10	82	56.3	162.9**[b]	1.99	6.16	310	267	
	1	3	6	64	94.3	99.3	1.55	5.50	354	271	1.26
	2	4	6	64	93.7	104.7	1.64	6.36	389	303	1.38*[d]
2											
	3	5	6	64	94.0	112.0**[e]	1.75	5.42	309	278	1.50**[d]
	4	6	6	64	93.3	107.8	1.68	5.08	302	270	1.38*[d]
	1	3	10	70	54.7	119.3	1.70	5.98	351	270	1.36
	2	4	10	70	54.7	122.3	1.75	5.96	341	261	1.31
3											
	3	7	10	70	52.8	129.7*[e]	1.85	6.21	335	278	1.48**[f]
	4	5	10	70	52.5	143.5**[e]	2.05	6.36	310	279	1.49**[f]

* Significant at the 5% level.
** Significant at the 1% level.
[a] Supplemented with 20 gm. oxytetracycline per ton ration in form of Terramycin Animal Mix TM5, generously supplied by Chas. Pfizer & Co., Inc.
[b] LSD .05=7.9; .01=10.6.
[c] LSD .05=8.9; .01=12.1.
[d] LSD .05= .11; .01= .15.
[e] LSD .05=8.6; .01=11.6.
[f] LSD .05= .12; .01= .16.

Because the pigs were group fed, there can be no statistical analysis made on feed consumption or utilization data. In trial 1 it would appear definite that average daily feed consumption was increased in the tallow rations. Differences in feed consumption are not so great in trials 2 and 3 and are in different directions. Certainly there are no consistent indications that consumption of feed is lowered on the high fat rations.

Feed utilization was apparently poor in trial 1 on the high tallow rations. The difference in feed utilization between control lots 1 and 2 and tallow lots 3 and 4 are of the magnitude of the amount of tallow in the rations. In trials 2 and 3 feed per 100 lb. gain was lowered in the

TABLE 3. SUMMARY OF STATISTICAL ANALYSES

(Analysis of Variance—Mean Square)

Trial	Source of variation	Degrees of freedom	Average total gain	Backfat thickness
	Total	39		
	Error	36	75.42	
1	Fat	1	9455.63**	
	Oxytetracycline	1	15.63	
	Interaction	1	.03	
	Total	23		
2	Lots	3	171.15*	.0553**
	Error	20	54.28	.0078
	Total	39		
3	Lots	3	1164.53**	.0767**
	Error	36	84.63	.0166

* Significant at the 5% level.
** Significant at the 1% level.

higher fat rations. Calculated TDN utilization, however, appears to be the same on all rations in trials 2 and 3.

In trial 1 stabilized tallow had no replacement value, but in trials 2 and 3, 100 lb. of tallow were replaced by approximately 312 lb. of barley less 44 lb. of supplement.

Tallow rations were very palatable and readily consumed. They were less dusty and fed more slowly through the self feeders resulting in less feed waste. Pigs consuming tallow and lard had excellent bloom of hair coat, and in this respect were noticeably better than controls. Whether or not this was due to internal or external use of the fat was not determined, but no observations were made which indicate this bloom was due to external ration (fat) application.

In the flavor study conducted in conjunction with trial 1, the taste

panel as a whole was unable to distinguish between the pork produced on the control and 10% tallow rations. Of those judges who were able to distinguish between the samples, a slight preference for the tallow-fed pork was indicated but lacked statistical significance. No off-flavor was indicated in tallow-fed pork. Separation was not made on the basis of flavor, but on the basis of fatness, since the tallow-fed pigs were significantly heavier and fatter (table 2).

Addition of oxytetracycline in trial 1 (tables 2 and 3) was without effect on either the control or tallow rations.

Summary

Three trials with 104 pigs have been run to test their response to rations containing 5 and 10% stabilized renderers tallow and 10% stabilized lard. In one trial oxytetracycline supplement was tested at a level of 20 gm. per ton of ration.

Tallow supplementation increased weight gain in all cases (10% tallow significant at the 1% level of significance and 5% tallow at the 5% level of significance). Feeding of 10% lard was without significant effect on weight gain. Backfat thickness was increased significantly on the high-fat rations but by no more than would be expected because of greater body weight.

Results of feed consumption were variable, but there were no consistent indications of lowered consumption on the high-fat rations. Feed utilization was poor on the tallow rations in trial 1 where tallow had no replacement value. Feed utilization was increased in trials 2 and 3 by tallow and lard feeding but by no more than the difference in calculated total digestible nutrient content due to increased fat content.

In one trial oxytetracycline supplement was without effect.

A taste panel test in one trial was unable to distinguish between tallow-fed pork and controls and failed to detect off-flavor in tallow-fed pork.

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PROTEIN LEVELS WITH AND WITHOUT AN ANTIBIOTIC FOR GROWING-FINISHING SWINE FED ON LEGUME PASTURE [1]

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A CONSIDERABLE amount of evidence has been accumulated recently that substantiates the suggestion of Cunha *et al.* (1950) that swine might perform well on lower protein allowances than previously recommended. Reports of Catron *et al.* (1952), Burnside *et al.* (1954) Wallace *et al.* (1954), Lassiter *et al.* (1955), Hanson *et al.* (1955), Becker *et al.* (1955), Jensen *et al.* (1955) and Meade (1956) have shown that swine rations adequate in other dietary factors result in comparable weight gains and feed efficiency using protein levels 2 to 3 units percent less than formerly believed necessary for best performance. A nitrogen balance study, employing soybean oil meal as the source of protein, was reported by Armstrong and Mitchell (1955) which showed 16% of protein was in excess of the needs for pigs weighing initially from 20.6 to 25.7 kg.

The preponderance of the above data was collected under dry lot conditions. However, Lassiter *et al.* (1955) and Becker *et al.* (1955) reported on the response of pigs to different levels of protein when fed on pasture. The first report showed that pigs fed 12% protein from a beginning weight of about 30 lb. to a final weight of 200 lb. made weight gains comparable to pigs fed a 14% ration, but feed efficiency was poorer than for pigs fed the 14% ration. One test in the latter report showed that by the equalized feed intake method pigs fed on a 12% protein ration made better weight gains and with greater efficiency than pigs on any of the other levels of protein tested from a weight of approximately 40 lb. to 200 lb.

The present experiment was designed to study the protein level with and without an antibiotic that would result in most rapid weight gain and most efficient feed conversion when pigs were self-fed complete rations on pasture during the grazing season of 1953 and 1954.

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Experimental

Experimental Design. A randomized block design was employed for this project. The blocks were made up on the basis of initial weight of the pigs within the sexes. The ration treatments consisted of six protein levels and each level was fed with and without the antibiotic which resulted in a total of 12 ration treatments.

Six pigs in all, two barrows and one gilt each year, were subjected to each ration treatment. Each animal was considered an experimental unit and the data for the response criteria, gain, feed intake, feed efficiency and live back fat depth were analyzed statistically according to

TABLE 1. ANALYSIS OF VARIANCE PLAN

Source of variation	Degrees of freedom		Degrees of freedom	
	30 to 75 lb.		30 to 200 lb.	
Replication[a]		5		5
Protein levels		5		4[b]
Linear regression component	1		1	
Quadratic regression component	1		1	
Remainder	3		2	
Antibiotic		1		1
Antibiotic × protein levels		5		4[b]
Experimental error		55		44
Total		71		58[c]

[a] Includes sex and year effects.
[b] Data were not available from pigs fed the 8% protein rations.
[c] One missing value estimated.

the analysis of variance plan below. All references to statistical significance in the text pertain to the P=0.05 level. (Table 1).

Animals. In each of the two years 36 Poland China × Landrace × Duroc pigs were randomly alloted to the 12 ration treatments. The average starting ages and weights were 44 and 66 days, and 27 and 34 lb., respectively, for 1953 and 1954.

Equipment. The pigs were confined to the portable pasture units recently described by Ashton *et al.* (1956) and which were located on pasture composed predominately of alfalfa in both years.

The pigs were placed on experiment on May 26 and June 10 in 1953 and 1954, respectively. The pasture was clipped periodically in an effort to maintain a supply of forage that was in the growing stage. The units were moved approximately the length of the unit to fresh pasture three times each week.

Rations. Experimental rations calculated to contain 8, 10, 12, 14, 16 and 18% crude protein were fed with and without 5 mg. per lb. of ration of the antibiotic chlortetracycline hydrochloride. Constant protein levels were self-fed to the individual pigs from the beginning of the experiment until each pig reached a live weight of 200 lb. This procedure provided data suitable for the Agricultural Economics Department to derive substitution values of corn and soybean oil meal when fed to pigs on pasture (McKee, 1955).

TABLE 2. COMPOSITION OF THE 8% AND 18% PROTEIN RATIONS

Ingredients [a]	8% protein		18% protein	
	1953	1954	1953	1954
Ground yellow corn	97.00	97.25	71.60	73.05
Solvent soybean oil meal (blended)	0.15		25.90	24.50
Calcium carbonate	0.90	0.50	1.00	0.70
Dicalcium phosphate	1.40	1.70	0.95	1.20
Iodized salt	0.50	0.50	0.50	0.50
Trace mineral mixture	0.05	0.05	0.05	0.05

[a] The calculated vitamin content of the rations was adjusted for the various protein levels to supply the following per lb. of complete rations: 3000 I.U. vitamin A, 400 I.U. vitamin D_2, 1.5 mg. riboflavin, 5.5 mg. pantothenic acid, 20 mg. niacin, 450 mg. choline chloride and 5 mcg. vitamin B_{12}.

The calcium and phosphorus contents were held constant at 0.7 and 0.5%, respectively. The trace mineral mixture supplied in ppm, iron 35, copper 2.4, cobalt 0.8, manganese 28.5 and zinc 2.2.

The variation in proportion of ingredients between the two seasons was due to differences in protein and mineral contents of the ground yellow corn and soybean oil meal. The 8% protein ration fed in 1954 actually calculated 9.1% protein due to the 9.3% protein content of the corn used.

The composition of the ration protein extremes are shown in table 2. Calculations of crude protein, calcium and phosphorus were based on previously analysed ingredients.

Results

Performance data for the two pasture seasons are summarized in table 3 for weight gain periods from 30 to 75 lb. and 30 to 200 lb.

The level of protein fed during the 30 to 75 lb. period, showed a definite increase in daily gains as the level of protein was increased. Protein levels higher than 14% produced only slight increases in gain, whereas increasing increments of protein from 8 to 14% resulted in 0.2 to 0.3 lb. increase in daily gain for each 2 units change in protein level. Daily feed increased with increasing levels of protein to 14% and then decreased.

TABLE 3. SUMMARY OF GAINS, FEED AND LIVE BACK FAT DATA[a]

Level of antibiotic[b]	Percent protein in ration						
	8	10	12	14	16	18	Av.
Beginning to 75 lb.							
Daily gain							
None	0.62	0.82	1.19	1.35	1.37	1.38	1.12
5 mg.	0.43	0.91	1.10	1.36	1.45	1.48	1.12
Av.[c]	0.52	0.86	1.14	1.36	1.41	1.43	
Daily feed consumption							
None	2.38	2.74	3.23	3.63	3.32	3.38	3.11
5 mg.	1.90	2.80	3.16	3.58	3.69	3.59	3.12
Av.[c]	2.14	2.77	3.20	3.60	3.50	3.48	
Feed per lb. gain							
None	4.10	3.40	2.71	2.70	2.44	2.46	2.97
5 mg.	4.88	3.13	2.90	2.64	2.56	2.44	3.09
Av.[c]	4.49	3.26	2.80	2.67	2.50	2.45	
Beginning to 200 lb.							
Daily gain							
None		1.30	1.65	1.65	1.61	1.53	1.55
5 mg.		1.27	1.53	1.68	1.68	1.65	1.56
Av.[c]		1.28	1.59	1.66	1.64	1.59	
Daily feed consumption							
None		4.62	5.26	5.28	5.25	5.01	5.08
5 mg.		4.35	4.82	5.14	5.25	5.28	4.97
Av.[c]		4.48	5.04	5.21	5.25	5.14	
Feed per lb. gain							
None		3.54	3.18	3.20	3.26	3.29	3.29[b]
5 mg.		3.45	3.14	3.07	3.14	3.20	3.20
Av.[c]		3.50	3.16	3.14	3.20	3.24	
Depth of back fat (av. 2 live probes)							
None		1.43	1.60	1.52	1.55	1.33	1.49
5 mg.		1.55	1.57	1.60	1.57	1.55	1.57
Av.		1.49	1.58	1.56	1.56	1.44	

[a] Values for gain and feed data are lb., those for live back fat measurements are inches.
[b] Effect of antibiotic significant at P=0.05 or less.
[c] Quadratic regression significant at P=0.05 or less.

Feed efficiency showed a dramatic improvement from 8 to 12% protein level in the diet and it showed a continued improvement at a reduced rate on up to 16% protein. Statistical analysis of the above response criteria in each case showed significant quadratic effects. The

addition of the antibiotic, chlortetracycline, had no beneficial effect on the performance of the pigs in regard to gains, feed intake or feed efficiency.

Summarizing the entire feeding period, the maximum growth rate occurred on the ration containing 14% of protein, then decreased slightly with higher levels of protein. The performance of pigs fed the 8% ration during the 1953 season was completely unsatisfactory even after 75 lb. and freezing weather necessitated termination of this group of pigs before reaching 200 lb. During 1954 the pigs fed the 8% ration did considerably better, three of them attaining a weight of 200 lb. before the first killing frost of the season. Daily feed intake for all practical purposes reached a maximum at 14% protein and feed conversion was most efficient at this level. The levels of protein again showed a significant quadratic response for each of the above measurements. There was no improvement from the addition of the antibiotic on gains or feed intake, but a significant difference did occur for the feed efficiency, there being a 9 lb. saving in feed per 100 lb. gain in favor of antibiotics. The differences in live back-fat measurements were not statistically significant either for the antibiotic or protein level treatments.

Discussion

The results obtained in this experiment with respect to protein levels bear a striking resemblance to the data reported by Jensen *et al.* (1954) even though the latter experiments were conducted under concrete drylot conditions. Weight gains followed a similar pattern showing a maximum at 14% in the presence of antibiotics. It should be noted that in this experiment there was not a significant effect from the addition of the antibiotic. Though caution should be exercised in comparing these experiments, the pigs fed on pasture (reported on herein) required an average of 17 lb. more feed per 100 lb. gain than did the pigs fed under concrete drylot conditions from beginning to 75 lb. when protein levels from 10 to 18% are compared. It is interesting to speculate why this situation should exist even though this growth period took place during the early part of the pasture season when pasture quality would normally be expected to be good. A comparison of the summary at 200 lb. shows that a saving in feed occurred on pasture, possibly indicating that the heavier pig is capable of utilizing pasture to advantage. These data follow a similar pattern as those reported by Lassiter *et al.* (1955) in that the growth response reached a maximum at 14% protein. Their

summary showed a considerable feed saving in favor of pasture feeding compared to concrete drylot feeding, especially from a starting weight of approximately 30 lb. to 100 lb.

During both pasture seasons it was observed that those pigs on the lower protein levels ate more pasture than those on 12% or higher protein levels, but this obviously resulted in no advantage in feed saving, or rate of gain. Recently Bohman *et al.* (1955) reported decided reductions in gain and increased feed requirements with increasing levels of alfalfa meal when a protein level of approximately 20% was fed. On the other hand, Beeson *et al.* (1953) reported very satisfactory growth and feed efficiency when pigs fed on ladino clover pasture received only corn, minerals and an antibiotic supplement. Gains were improved by adding enough supplement to the corn and mineral ration to furnish a 14% protein ration, however, feed efficiency was not improved.

Becker *et al.* (1955) in a series of equalized feeding experiments found that 12% protein supported maximum gains and efficiency when a single protein level was fed from weaning to 100 lb., whereas from 100 to 200 lb. a ration of corn, minerals, vitamins and antibiotics was adequate if adequate protein was fed up to 100 lb.

Several phenomena appear to be occurring in this experiment as well as other pasture work cited herein. When a well-balanced ration is self-fed *ad libitum* to pigs forage consumption is reduced. By limiting feed intake or by creating a nutrient imbalance, for example protein, more forage will be consumed. The benefit derived from pasture varies considerably among the plant species and even in the quality of the same species. Also, the heavier market pig is apparently capable of utilizing forage to better advantage than the young pig, yet in commercial production it is the practice to grow pigs on pasture and finish them in drylots. The use of the "chromogen technique" which has been an important tool in studying ruminant nutrition under grazing conditions should allow one to get an actual measurement of forage consumption and digestibility. These measurements would be necessary to verify the above postulations.

Summary

Rations of corn and soybean oil meal fortified with minerals and vitamins were fed to pigs individually at different protein levels of 8, 10, 12, 14, 16 and 18% with and without chlortetracycline hydrochloride from approximately 30 lb. up to 200 lb. on alfalfa pasture.

Each of the response criteria including growth, feed intake, and feed efficiency showed a statistically significant quadratic effect for the level of protein fed during the 30 to 75 lb. period and from 30 to 200 lb. period. A maximum was reached in gains and feed efficiency at 16% protein up to 75 lb. and at 14% protein up to 200 lb. There was no effect from the addition of the antibiotic on gains or feed intake but it did affect the efficiency during the overall period, though this effect was small. The differences in the live probe measurements of back fat were not shown to be attributable to ration treatment.

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THE EFFECT OF HIGH LEVEL ANTIBIOTIC SUPPLEMENTATION DURING PART OR ALL OF THE GROWING-FATTENING PERIOD OF SWINE [1]

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THE value of antibiotics in swine rations has been adequately reviewed by Braude *et al.* (1953). They stated that, in general, studies dealing with the level of antibiotic supplementation were inconclusive. The optimum level at which antibiotics should be fed appears to vary with the nature of the ration, the antibiotic used and the condition or general thrift of the pigs. Early work by Edwards *et al.* (1950) and Cunha *et al.* (1951) showed increased gains when levels of 50 to 180 gm. per ton of chlortetracycline (Aureomycin) were used as compared to lower levels. These trials were of short duration, 37 or 52 days, and utilized a corn-peanut-meal ration. Recently several workers have reported varying success when antibiotics were fed to pigs at levels of 50 to 100 gm. per ton of feed (Beeson and Conrad, 1955; Davey *et al.*, 1955; Hanson, 1955, and Meade and Teter, 1955).

The studies reported herein were initiated to determine the value of high levels of chlortetracycline and a penicillin-streptomycin mixture [3] (Pro-Strep), when fed to pigs during the growing-fattening period and also to determine the feasibility of reducing or discontinuing the high level antibiotic supplementation when the pigs reach a weight of approximately 100 lb.

Experimental Procedure

Three trials were conducted with 120 weanling pigs averaging 29 to 31 lb. initially. Purebred Duroc, Hampshire, Poland China and Spotted Poland China pigs were used except for 20 crossbred Hampshire × Poland China and Hampshire × Spotted Poland China pigs used in Experiment 2. The pigs used in Trial 1 were farrowed in June and had been raised on good alfalfa pasture prior to weaning at about 7 weeks of age. Those fed in Trials 2 and 3 were fall-farrowed pigs

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[3] This mixture contained 25% penicillin and 75% streptomycin.

TABLE 1. EXPERIMENTAL PLAN

Lot no.	Antibiotic supplementation[a] (gm./ton)		
	Trial 1	Trial 2	Trial 3
1	None	None	None
2	100 gm. C	10 gm. C.	10 gm. PS
3	25 gm. PS	100 gm. C to 100 lb. None 100 to 200 lb.	100 gm. PS to 100 lb. None 100 to 200 lb.
4	50 gm. PS	100 gm. C to 100 lb. 10 gm. C 100 to 200 lb.	100 gm. PS to 100 lb. 10 gm. PS 100 to 200 lb.
5	100 gm. PS	100 gm. C	100 gm. PS

[a] C=chlortetracycline and PS=penicillin-streptomycin mixture 1:3.

that had been raised on poor rape pasture prior to weaning. In each experiment the pigs were sorted into groups as equally as possible according to litter and weight and the groups were allotted to the various treatments at random. All pigs were kept in a barn with concrete-floored pens and had access to adjacent outside paved runways. All rations were self-fed and an automatic water supply was provided.

The basal ration used in all 3 trials was composed of 81% ground yellow corn, 12% soybean oil meal, 6% tankage, 0.5% steamed bone meal and 0.5% trace mineralized salt. The ration was fortified with 2 mg. riboflavin, 4 mg. pantothenic acid, 9 mg. niacin, 10 mg. choline and 5 mcg. vitamin B_{12} per pound.

The experimental plan describing the various treatments is given in table 1. In all experiments the growth data were treated statistically by analysis of variance as outlined by Snedecor (1946).

TABLE 2. THE EFFECT OF VARIOUS LEVELS OF ANTIBIOTICS ON GROWTH RATE, FEED CONSUMPTION AND FEED EFFICIENCY OF GROWING PIGS

Item	Control	Chlortetra-cycline	Penicillin-strepto-mycin[a]	Penicillin-strepto-mycin	Penicillin-strepto-mycin
Antibiotic, gm./ton	0	100	25	50	100
Number of pigs[b]	12	12	12[c]	12[c]	12
Av. initial wet., lb.	29.5	29.4	29.5	29.6	29.3
Av. final wt., lb.	159.0	185.9	177.3	173.2	178.1
Av. daily gain, lb.	1.54	1.86	1.76	1.71	1.77
Av. daily feed, lb.	5.00	5.95	5.80	5.27	5.44
Feed/cwt. gain, lb.	325.0	319.7	329.7	308.3	307.1

[a] Penicillin-streptomycin mixture 1:3.
[b] Two lots of six pigs each per treatment.
[c] The figures include a calculated missing value, since one pig in each lot died from unknown causes (Snedecor, 1946).

TABLE 3. ANALYSIS OF VARIANCE OF MEAN DAILY GAINS FOR TRIAL 1

Source of variation	Degree of freedom	Mean square
Treatment	4	0.1702**
Outcome groups	11	0.0561
Error	42	0.0409

** Significant at the 1% level.

Results and Discussion

The results of the first trial are summarized in table 2. In general, the pigs in all lots made excellent gains. It was observed that the pigs receiving the antibiotic rations gained much more rapidly during the first 6 weeks of the experiment. Thereafter there was little difference in rate of gain between groups although the small difference was in favor of the pigs fed antibiotics. The analysis of variance, presented in table 3 shows that the treatments exhibited a statistically highly significant effect ($P<0.01$) upon the weight gains. There was very little difference in rate of gain between the lots of pigs receiving 25, 50 or 100 gm. of penicillin-streptomycin per ton of ration.

TABLE 4. THE EFFECT OF CHLORTETRACYCLINE ON THE PERFORMANCE OF GROWING-FATTENING PIGS [a]

Lot no.	Chlortetracycline per ton	Av. daily feed	Av. daily gain	Feed per 100 lb. gain
	gm.	lb.	lb.	lb.
		Weaning to approximately 100 lb.		
1	None	3.13	1.11	282
2	10	3.77	1.49	254
3	100	4.17	1.58	264
4	100	4.21	1.60	263
5	100	4.29	1.64	262
		Approximately 100 to 200 lb.		
1	None	6.54	1.82	361
2	10	7.36	1.99	370
3	None	6.93	1.88	370
4	10	6.33	1.75	362
5	100	7.32	2.04	360
		Weaning to 200 lb.		
1	None	4.89	1.48	332
2	10	5.86	1.79	329
3	100–None	5.79	1.75	331
4	100–10	5.48	1.69	325
5	100	5.99	1.86	322

[a] Six pigs per lot, average initial weight 31 lb.

The feed required per unit of gain was slightly in favor of the pigs fed the higher levels of penicillin-streptomycin. Lots 4 and 5, which were fed 50 and 100 gm. of penicillin-streptomycin per ton of ration, required approximately 5% less feed per cwt. than did the pigs in the basal lot.

TABLE 5. THE EFFECT OF A PENICILLIN-STREPTOMYCIN COMBINATION ON THE PERFORMANCE OF GROWING-FATTENING PIGS [a]

Lot no.	Pen.-strep.[b] per ton	Av. daily feed	Av. daily gain	Feed per 100 lb. gain
	gm.	lb.	lb.	lb.
		Weaning to approximately 100 lb.		
1	None	3.85	1.26	305
2	10	3.62	1.38	263
3	100	3.90	1.48	263
4	100	4.10	1.45	282
5	100	3.87	1.51	257
		Approximately 100 to 200 lb.		
1	None	6.46	1.73	373
2	10	6.65	1.65	404
3	None	6.59	1.67	395
4	10	6.87	1.79	385
5	100	6.41	1.75	366
		Weaning to 200 lb.		
1	None	5.24	1.52	346
2	10	5.45	1.54	354
3	100–None	5.50	1.60	345
4	100–10	5.68	1.65	345
5	100	5.28	1.65	321

[a] Six pigs per lot, average initial weight 31 lb.
[b] Penicillin-streptomycin 1:3.

The average performance data for the pigs fed chlortetracycline in Trial 2 and penicillin-streptomycin in Trial 3 are shown in tables 4 and 5. The summary of the analysis of variance for these two trials is given in table 6.

The addition of chlortetracycline to the ration during the early growth phase resulted in a significantly faster rate of gain at both the 10 and 100 gm. per ton levels. Although not statistically significant, the higher level of antibiotic supplementation gave a growth increase of 8% more than the low level of supplementation. The increased gains were just slightly below the significance level at the 5% point (L.S.D.= 0.16). The data for this early growth phase are based on the performance

of the antibiotic-fed pigs for six weeks and the control lot for 8 weeks. During the first 4 weeks of the experiment the rates of gain of the controls, low level and average of the high level lots were: 1.11, 1.28, and 1.55 lb. per day, respectively. It was obvious that the pigs fed the high level of chlortetracyline got a much better start than the pigs which did not receive chlortetracycline or received the low level of supplementation.

Supplementing the ration with penicillin-streptomycin at 10 and 100 gm. per ton also resulted in increased gains over the control lot (table 5) during the early growth period. The high level of supplementation produced a 7% increase in rate of gain over the low level of penicillin-streptomycin during this period. In both Trials 2 and 3

TABLE 6. ANALYSIS OF VARIANCE OF MEAN DAILY GAINS FOR TRIALS 2 AND 3

Exp.	Source of variation	Degree of freedom	Mean square		
			Weaning to 100 lb.	100–200 lb.	Weaning to 200 lb.
2	Treatments	4	0.2745**	0.0808*	0.1296**
	Outcome groups	5	0.0797**	0.0750*	0.0655**
	Error	20	0.0180	0.0205	0.0116
3	Treatments	4	0.0591	0.0211	0.0209
	Outcome groups	5	0.1098*	0.0347	0.0331
	Error	20	0.0329	0.0366	0.0227

* Significant at the 5% level.
** Significant at the 1% level.

the pigs fed antibiotics required less feed per unit of gain than the control pigs during this early growth phase. There was essentially no difference in feed efficiency between the pigs fed the low or the high level of antibiotics from weaning to approximately 100 lb.

The rate of gain of the pigs from 100 to 200 lb. was not consistent between experiments. When chlortetracycline was used as the antibiotic the rates of gain were less in those lots where the antibiotic was removed or reduced in amount at 100 lb. than in those lots where it was fed at the previous level. This is in agreement with the reports of Wilson (1952) and Wallace *et al.* (1953). There was no difference in feed efficiency between the various treatments during this period.

In Trial 3, the 5 lots showed very little difference in rate of gain during the period from 100 to 200 lb. A slightly slower rate of gain was observed when the high level of penicillin-streptomycin was discontinued

at 100 lb. than when it was continued at the previous level. However, reducing the level of supplementation from 100 to 10 gm. per ton did not affect the gain during this period. The pigs in this trial did not gain as rapidly as those in Trial 2 and, in most cases, required more feed per unit of gain. The difference in feed efficiency between the two trials during this late growth phase may have been due in part to weather conditions. South Dakota experienced an abnormally cold December and January in 1955–56. Since Trial 2 was started 2 weeks earlier in the fall than Trial 3 and the pigs grew at a faster rate, the pigs in that trial were on the experiment about 4 weeks less during the extremely cold weather. Thus it is possible that some of the difference in feed efficiency during the late growth period may have been due to the colder weather. It has been observed at this Station (Wahlstrom *et al.*, 1954) that 8 to 15% more feed is required to produce a unit of gain in the winter as compared to summer feeding.

Growth response over the entire feeding period showed a significant difference due to chlortetracycline supplementation (Trial 2). The high level of chlortetracycline supplementation during the entire feeding period produced the fastest gains but the difference between the high and low levels was not as great as during the initial weeks of the trial. Discontinuing or reducing the high level of chlortetracycline when the pigs weighed 100 lb. reduced the daily gains below those of the pigs fed 10 gm. per ton continuously. The differences in feed per 100 lb. of gain were very small between lots, although they did favor the pigs fed chlortetracycline.

The feeding of penicillin-streptomycin resulted in small but statistically non-significant increases in rate of gain. The 100 gm. level and the 100 gm. level reduced to 10 gm. at a weight of 100 lb. produced the best daily gains over the entire feeding period. The continuous high level of penicillin-streptomycin did not have any marked advantage in rate of gain compared to reducing or discontinuing the high level supplementation at 100 lb. body weight. However, there was a feed saving of approximately 7% when the 100 gm. per ton level of penicillin-streptomycin was fed.

In both Trials 2 and 3 it was noted that during the first 6 weeks of the trials the high level of antibiotic supplementation resulted in a more uniform growth response than did the lower level of supplementation. It is possible that the young pigs did not all consume enough feed to receive maximum antibiotic response during this time unless a high level of antibiotic was fed. The value of high-level antibiotic sup-

plementation will probably vary with the health and thrift of the pigs as well as management and environmental conditions.

Summary

In one trial 60 weanling pigs were fed in 10 replicated lots to study the value of 3 different levels (25, 50 and 100 gm. per ton) of a penicillin-streptomycin mixture and the value of a high level (100 gm. per ton) of chlortetracycline when added to a mixed ration. The addition of the antibiotics produced a highly significant ($P<0.01$) increase in rate of gain. There was very little difference in the rate of gain of the pigs fed the different levels of penicillin-streptomycin. The pigs fed the two higher levels of penicillin-streptomycin required 5% less feed than the control group.

Two trials were conducted to compare the value of high and low level antibiotic supplementation and to determine the feasibility of withdrawing or reducing the high level supplementation at a weight of approximately 100 lb.

In the one trial involving chlortetracycline there was a significant increase in rate of gain from all antibiotic treatments. The high level of chlortetracycline 100 gm. per ton resulted in consistently faster gains than 10 gm. per ton during the early growth period. Withdrawing or reducing the high level to 10 gm. per ton at 100 lb. had a depressing effect on feed intake and daily gains during the period from 100 to 200 lb.

Pigs fed penicillin-streptomycin gained faster than control pigs but the differences were not significant at the 5% level. Supplementation with a high level of penicillin-streptomycin resulted in consistently faster rates of gain than the low level of this antibiotic during the early growth period as was true for chlortetracycline. Gains were reduced when penicillin-streptomycin was removed at 100 lb. but not when it was reduced to 10 gm. per ton. The high level of penicillin-streptomycin increased feed efficiency 7% over the control group.

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THE UTILIZATION OF A HIGH LEVEL OF ALFALFA BY GROWING-FATTENING SWINE

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RECENT work (Kidwell and McCormick, 1952; McCormick and Kidwell, 1953; Bohman *et al.* 1953, 1955) has indicated that swine might gain an average of 1.0 to 1.7 lb. daily during the entire growing-fattening period when alfalfa constituted 50% of the ration. Average daily gain of comparable animals receiving a conventional ration ranged from 1.7 to 2.1 lb. Carcasses of pigs fed the high level of alfalfa had less backfat and yielded a higher proportion of lean cuts than those fed a conventional ration. These results suggest the use of higher levels of alfalfa.

It is important to determine, in terms of the amount of concentrate replaced, the extent to which the alfalfa in such rations is utilized. Estimates obtained from previous experiments indicate a pound of alfalfa might replace 0.13 to 0.50 lb. of concentrate per pound of gain. These estimates, however, are not amenable to statistical tests of significance.

This experiment was designed to provide an estimate of alfalfa utilization by growing-fattening swine when alfalfa constitutes 50% of the ration, and to provide further data concerning the influence of high levels of alfalfa on carcass quality.

Materials and Methods

Twelve weanling pigs were divided into two groups of six pigs each on the basis of dam, sex and weight. The pigs were sired by a single boar, and farrowed by three closely related sows during a one week period. The pigs were of a cross-bred Landrace × Large Black × Hampshire × Poland-China × Duroc foundation developed by the Louisiana Agricultural Experiment Station. Uniform preweaning conditions prevailed. The two groups were, therefore, quite similar and uniform. One group was fed a conventional ration and the other a ration containing 50% alfalfa (tables 1 and 2). The pigs were maintained and self-fed in individual pens and shelters. The shelters were approximately 5 feet square, and the pens 5×12 feet.

[1] Department of Animal Husbandry, Reno, Nevada. The authors are indebted to the American Cyanamid Company for providing the chlortetracycline and to the Charles Pfizer Company for providing the vitamin A used in this experiment.

TABLE 1. PHYSICAL COMPOSITION OF THE RATIONS

Ingredients[a]	Alfalfa	Control[b]
	%	%
Alfalfa	50.0	00.0
Meat scrap	5.0	12.5
Soybean oil meal	5.0	5.0
Salt	0.5	0.5
Barley	39.5	82.0

[a] Both rations contained 10 mg. chlortetracycline per pound and both rations were pelleted.
[b] 1500 I.U. Vitamin A added per pound.

The pigs were slaughtered at approximately 200 lb. live weight. The data include: initial weight, final weight, feed consumption, hot carcass weight, chilled carcass weight; weight of hams, shoulder, loin, bacon; length (aitch bone to first rib) and backfat thickness. The data were amenable to analysis of variance, single classification, two subgroups as described by Snedecor (1946).

Results and Discussion

Moderate to heavy scouring was observed among several pigs receiving the high alfalfa ration. This was most severe when the pigs weighed less than 100 lb. One case of rectal prolapse was encountered, but it responded to surgical treatment. Scouring has been observed among pigs fed high alfalfa rations in earlier experiments.

Growth, feed utilization and carcass data are presented in table 3. Rate of gain was similar to that observed in previous trials. An average daily gain of 1.4 lb. during the growing-fattening period would permit pigs to reach 200 lb. at less than six months of age and would, therefore, pose no special management problem.

The group fed alfalfa consumed 1.14 lb. less concentrate per pound

TABLE 2. CHEMICAL COMPOSITION OF RATIONS AND ALFALFA

Item	Dry matter	Composition of dry matter						
		Crude protein	Ether extract	Crude fiber	N.F.E.	Ash	Ca	P
	%	%	%	%	%	%	%	%
50% alfalfa ration	89.97	19.71	2.47	17.47	50.83	9.52	2.62	0.63
Control ration	89.90	20.80	3.36	6.91	60.67	8.26	2.67	1.09
Alfalfa meal[a]	95.01	16.65	1.37	33.82	37.55	10.61	2.04	0.25

[a] Third cutting harvested and field cured in the early bud stage of maturity.

of gain than the control group. In addition, they consumed 2.25 lb. of alfalfa per pound of gain. The difference in concentrate consumption per pound of gain was significant at the 1% level, with 5% fiducial limits of 0.50 and 1.78. It can, therefore, be concluded that 1 lb. of alfalfa replaced 0.51 lb. of concentrate. The 5% fiducial limits would be 0.22 to 0.79 lb. These data indicate that for profitable production at this level, alfalfa in the ration must cost less than half as much as the grain and supplement.

TABLE 3. GROWTH, FEED UTILIZATION AND CARCASS DATA

Item	50% alfalfa	Control
Growth and feed utilization		
Average, lb.		
Initial weight	45.2	41.8
daily gain	1.4*	1.8
Total feed per pound gain	4.50*	3.39
Grain and supplement per pound gain	2.25*	3.39
Carcass quality		
Dressing percent[a]	62.4*	69.0
Length, in.	28.5	27.9
Backfat thickness, in.[b]	1.1*	1.7
Percent of cold carcass		
Trimmed ham	22.7*	20.3
Trimmed loin	15.7	13.9
Trimmed shoulder	18.6*	17.4
Untrimmed bacon	18.5	19.1

* Difference significant at 1% level.
[a] Determined on basis of shrunk live weight and cold dressed weight, packer style.
[b] Average of three measures taken at the first and last rib and opposite the last lumbar vertebra.

These results are similar to those of previous experiments. Kidwell and McCormick (1952) found that one group of growing-fattening swine receiving a 50% alfalfa ration consumed 5.75 lb. of feed per pound of gain compared to 4.66 lb. of feed per pound of gain consumed by a similar group receiving 10% alfalfa in the ration. The group receiving 50% alfalfa consumed 1.1 lb. less of grain and 2.2 lb. more of alfalfa per pound of gain than those receiving 10% alfalfa. It was estimated therefore, that at this level 1 lb. of alfalfa replaced 0.5 lb. of grain and protein supplement. The data of Bohman *et al.* (1955) provide estimates of grain and concentrate replacement values per pound of alfalfa of 0.14 and 0.13 lb. per pound of gain when rations containing zero and 50% alfalfa, with and without chlortetracycline, were compared. The pigs were group fed in these experiments, precluding a

test of significance of the observed differences in grain and alfalfa utilization. The alfalfa used in the experiments of Bohman *et al.* was lower in protein and higher in fiber than that used in these experiments and probably adversely affected the replacement values. The results of this experiment and consideration of the previous experiments indicate that 1 lb. of high quality alfalfa will replace 0.5 lb. of concentrate in the ration of growing-fattening pigs.

It should be noted that two compensating errors occur in the calculation of these estimates of the replacement value of alfalfa. The lower rate of gain of pigs receiving 50% alfalfa results in a longer feeding period, and consequently a relatively greater use of feed for maintenance. This error might have been avoided by restricting feed intake of the control group to equalize rate of gain between groups. This would have resulted in a higher replacement value for alfalfa. Since feed intake of growing-fattening pigs is rarely restricted in commercial production, it was not considered desirable to introduce this refinement. The second error arises because the pigs receiving 50% alfalfa store a greater proportion of muscle and a lower proportion of fat than the controls (table 3). Consequently, the energy content of the weight gain is lower for the animals receiving the high level of alfalfa. This error is not likely to be of importance from a production standpoint.

The variation among animals with respect to feed utilization is of interest. The range in feed requirement for the pigs receiving 50% alfalfa was from 3.6 to 4.9 lb. of feed per pound of gain. Comparable figures for the control group are 2.8 to 4.6 lb. The data do not provide an estimate of the relative importance of genetic and environmental influences on the observed variation. They suggest however, that it might be possible to develop lines adapted to the utilization of high levels of alfalfa.

In view of the high genetic relation and uniform management among the experimental animals, it seems reasonable to largely attribute differences in carcass quality to the rations. Highly significant differences were observed between groups for dressing percent, percent ham, percent shoulder, and backfat thickness. There were no differences with respect to percent loin, percent bacon, or length. These results are in general agreement with those of Bohman *et al.*, except for the significant differences in percent loin and bacon belly observed by these investigators. It seems reasonable to conclude that the pigs fed high levels of alfalfa will have a lower dressing percent, a lower proportion of fat and fat cuts, but a greater percent of lean cuts than those fed a standard ration.

Summary and Conclusions

Twelve pigs farrowed by three related sows and sired by a single boar were divided into two groups and fed individually during the growing-fattening period. One group received a conventional ration and the other a ration containing 50% alfalfa. The results indicate that at this level 1 lb. of alfalfa will replace 0.5 lb. of grain and supplement. It was also observed that the pigs receiving 50% alfalfa had a lower dressing percent, lower proportion of fat cuts and a higher percentage of lean and lean cuts.

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SWINE FEEDING EXPERIMENTS WITH COOKED RESIDENTIAL GARBAGE [1]

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FOLLOWING the national spread of vesicular exanthema in 1952, and subsequent legal requirements for the cooking of garbage before feeding to swine (Stuart, 1955; Joint Legislative Committee, 1955), California swine feeders were faced with feeding cooked garbage, a feed with which they were unfamiliar. Available information from New Jersey (Hunter, 1919), Hawaii (Willett *et al.*, 1948), and California (Joint Legislative Committee, 1953) indicated that cooked garbage was not equal to raw garbage in feeding value. One study (Willett *et al.*, 1948) demonstrated actual nutrient destruction in dried garbage.

A brief study (Perry and Schroeder, 1954) showed that properly cooked residential garbage was not only palatable but an economical swine feed. More research was needed, however, to define the feeding value of cooked garbage.

Experimental

The three trials reported herein were conducted as a cooperative project between the University of California Agricultural Experiment Station and the Agricultural Extension Service, Los Angeles County. They were conducted on a large garbage feeding ranch [4] in Los Angeles County with a member of the Experiment Station staff resident.

A series of 12 brooder units were used for the feeding trials. These units consisted of shed space with a dirt exercise pen to the south and a concrete feeding pen to the north. Four pigs were housed in each unit. The pigs used were Hampshire barrows and gilts.

The residential garbage was typical of Southern California and was reasonably well segregated, even though the occurrence of paper, cans, bottles, etc., was not uncommon. It was hauled to the ranch in large trucks and semi-trailers which hold approximately 20 tons per load. The beds of the trailers have built in steam pipes which are connected to a steam generator by means of flexible hoses. The garbage was cooked by steam injection according to regulations of (Joint Legislative

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Committee, 1955) and under the supervision of (Bonnikson and Meyers, 1955) the State Department of Agriculture which require heating throughout to boiling or equivalent temperature for 30 minutes.

Following cooking, the garbage for experimental use was delivered by means of a mechanical unloader into a pile on a concrete slab. It was picked up by means of a scoop shovel for weighing and feeding. Some liquid loss was experienced, and the more obvious paper, bottles, and cans were eliminated from the feed before weighing.

Garbage was fed in wooden troughs to enable weighback collection even though the common practice is to feed the garbage on open concrete floors. Garbage weighbacks were made regularly except when interfered with by rain. Weighbacks are only relative because they contain some feces and urine, and some garbage was spilled on the concrete floor, badly tramped, and could not be recovered. Dry feeds were fed in a separate metal trough and were completely consumed. When antibiotic supplement was fed with no dry feed, it was thoroughly mixed with a small amount of choice garbage which was fed first and consumed before the remainder of the garbage was fed. Water was supplied in an automatic waterer.

Garbage was fed *ad libitum*. A feeding level of ⅓ to ½ weighback was established. Therefore, if the weighback fell below ⅓, the amount of garbage was increased; whereas, if it was over ½, the garbage was reduced.

In the various trials, rations were used as follows:

Trial 1—
- Group 1—Cooked garbage.
- Group 2—Cooked garbage plus barley.
- Group 3—Cooked garbage plus a barley-alfalfa meal mixture in equal parts.

Trial 2—
- Group 1—Cooked garbage.
- Group 2—Cooked garbage plus chlortetracycline.[5]
- Group 3—Cooked garbage plus barley.
- Group 4—Cooked garbage plus barley plus chlortetracycline.

Trial 3—
- Group 1—Cooked garbage (estimated weighback 20%).
- Group 2—Cooked garbage (estimated weighback 20%) plus chlortetracycline.
- Group 3—Cooked garbage (estimated weighback 33%).
- Group 4—Cooked garbage (estimated weighback 33%) plus chlortetracycline.
- Group 5—Cooked garbage (estimated weighback 50%).
- Group 6—Cooked garbage (estimated weighback 50%) plus chlortetracycline.

[5] Supplies of Aurofac-2A were generously supplied by Lederle Laboratories, Pearl River, N. Y. This product supplied 3.6 gm. of chlortetracycline per pound. Thus 12.5 gm. of Aurofac-2A were fed daily per head.

TABLE 1. RESULTS

(12 Units of 4 Pigs Each per Trial)

Trial	1			2				3					
Group	1	2	3	1	2	3	4	1	2	3	4	5	6
No. days	83			83				84					
No. units	4	4	4	3	3	3	3	2	2	2	2	2	2
Initial wt., lb.	63.9	63.7	66.9	51.5	52.7	49.9	51.6	28.2	27.2	27.5	28.6	30.2	24.0
Av. total gain, lb.	72.3	87.3	80.6[a]	57.7	72.6	67.0	86.8[b]	43.9	48.1	51.0	54.5	63.7	60.9[c]
Av. daily gain, lb. per pig	.87	1.05	.97	.70	.87	.81	1.05	.52	.57	.61	.65	.76	.72
Av. daily feed, lb. per pig													
garbage	21.8	21.8	21.8	23.6	23.6	23.6	23.6	16.4	16.6	25.0	25.0	36.1	36.1
dry feed		.45	.45			.44	.44						
Av. daily feed consumption, lb. per pig													
garbage	12.2	11.5	12.1	13.1	14.3	12.8	12.8[d]	12.3	12.7	15.7	15.9	17.8	17.2[e]
dry feed		.45	.45			.44	.44						
Weighback, percent	44.2	47.3	44.5	44.5	39.4	45.8	45.8[f]	24.7	23.2	37.1	36.5	50.7	52.4
Feed fed per pound gain, lb.													
garbage	25.1	20.8	22.6	34.1	27.0	29.3	22.4[g]	32.9	30.4	43.1	40.4	49.7	52.0
dry feed		.43	.47			.55	.46						
Feed consumed per pound gain, lb.													
garbage	14.0	11.0	12.5[h]	18.9	16.4	15.9	12.2[i]	23.9	22.3	25.9	24.5	23.5	23.7
dry feed		.43	.47			.55	.46						

[a] LSD $_{.05}$=7.8; LSD $_{.01}$=11.2
[b] LSD $_{.05}$=6.5; LSD $_{.01}$= 9.4
[c] LSD $_{.05}$=6.8; LSD $_{.01}$=10.3
[d] LSD $_{.05}$=0.9; LSD $_{.01}$= 1.2
[e] LSD $_{.05}$= .7; LSD $_{.01}$= 1.1
[f] LSD $_{.05}$=3.7; LSD $_{.01}$=5.3
[g] LSD $_{.05}$=1.7; LSD $_{.01}$=2.4
[h] LSD $_{.05}$=1.3; LSD $_{.01}$=1.9
[i] LSD $_{.05}$=1.3; LSD $_{.01}$=1.8

Where barley or the barley-alfalfa mixture was fed, the rate of 10% of the estimated dry matter requirement was used. Thus pigs weighing up to 80–85 lb. were fed 0.40 lb. each day. Above this weight they were fed 0.53 lb. each per day. Chlortetracycline [5] was supplied at a rate of 0.1 gm. daily per pig. At the start of the trials this would amount to the equivalent of approximately 2.5 gm. per 100 lb. of dry feed. As the animals increased in size this would become lower and approached 1.7 gm. of chlortetracycline per 100 lb. of dry feed.

TABLE 2. STATISTICAL ANALYSES

(Analysis of Variance—Mean Square)

Trial	Source of variation	Degrees of freedom	Total gain	Daily garbage consumption	Weighback	Garbage per lb. gain	
						Fed	Consumed
			lb.	lb.	lb.	lb.	lb.
	Total	11					
1	Group	2	225.02**	.53	12.01	12.52	6.97**
	Error	9	23.68	.90	19.30	3.81	.67
	Total	11					
	Antibiotic	1	906.54**	1.14	20.02	102.67**	19.00**
2	Grain	1	416.54**	2.52*	44.46*	39.24**	27.30**
	Interaction	1	18.01	1.14	20.87	4.20	
	Error	8	23.59	.40	7.56	1.59	.92
	Total	11					
	Garbage level	2	269.26**	25.30**			4.82
3	Antibiotic	1	7.84				2.62
	Interaction	2	15.44	.28			.97
	Error	6	15.33	.18			3.15

** Highly significant ($P<0.01$); * Significant ($P<0.05$).

Results and Discussion

It was apparent that there was more competition for feed among the garbage fed hogs than would be found with conventional rations. This caused a greater variation in weight gain among hogs than would ordinarily be expected. Gain data were analyzed according to the average of each unit of 4 pigs and variation among the units being treated the same. This was done rather than using individual variation because the unit of treatment was the group of 4 pigs rather than the individual. Animals were assigned to rations and units at random. Feed data were treated in the same manner.

Complete results are presented in table 1 and the analyses of variance in table 2.

The results show that a supplement of barley (as 10% of the dry matter requirement) increased weight gain 21 and 18% in trials 1 and 2, respectively, and that these increases were statistically highly significant ($P<0.01$). In trial 2 average daily garbage consumption was decreased, and weighback was increased by barley supplementation ($P<0.05$). Garbage fed per pound gain was decreased ($P<0.01$). Garbage consumption per pound of gain was decreased by barley supplementation in both trials 1 and 2 ($P<0.01$). One pound of barley replaced 9–10 lb. of cooked garbage in trials 1 and 2. Results with the supplemental mixture of equal parts barley and alfalfa (group 3, trial 1) were intermediate between the straight garbage group and barley supplemented groups. This mixture had a replacement value of one lb. mixture to 5 lb. of garbage, and the results would indicate that the mixture's value depended on its content of barley.

In trial 2, the addition of chlortetracycline increased weight gain about 28%, and this increase was statistically highly significant ($P<0.01$). The antibiotic addition decreased the garbage fed and consumed per unit of gain ($P<0.01$). This represented an increase in food utilization of almost 22%. The results of chlortetracycline supplementation in trial 3 failed to substantiate those in trial 2.

Level of garbage feeding was shown in trial 3 to affect rate of weight increase ($P<0.01$), though there was considerable weighback (about 24% at the lowest level of feeding). As the amount of garbage fed daily was increased from 16.5 to 25.0 to 36.1 lb. per pig daily, the weight increase was increased 15 and 18%, respectively. This increase in garbage fed caused an increase in actual garbage consumption of 26 and 11% ($P<0.01$). This increase in garbage level fed and consumed, however, did not affect the feed consumed per unit of gain. As the level of garbage fed was increased, however, as above, the pork produced per ton of garbage fed was decreased from 63 to 48 to 39 lb.

In trials 1 and 2 each ton of cooked garbage (when fed alone) produced about 80 and 60 lb. of pork, respectively.

The results indicate that the use of barley supplement and changes in the level of garbage feeding would depend upon the relative value of grain and garbage and the relationship of cost and supply of garbage to cost and supply of feeder pigs. The value of antibiotic supplementation is not yet established because of equivocal results in these two trials.

Summary

Three trials have been run with 12 pens of 4 hogs each per trial (48 hogs per trial). These hogs were fed cooked residential garbage typical of Southern California garbage feed.

The addition of 10% barley increased weight gain in 2 trials. One pound of barley replaced 9 to 10 lb. of garbage.

In one of two trials, supplementation with chlortetracycline increased weight gain and increased feed utilization about 22%.

Increasing the level of garbage fed daily increased the daily garbage consumption and weight gain, but decreased the pork produced per ton of garbage fed.

In these experiments a ton of unsupplemented residential garbage produced from 39 to 80 lb. of pork. At the level of garbage feeding established (weighbacks approximately 40%), a ton of unsupplemented residential garbage produced 48 to 80 lb. of pork under the condition of these experiments.

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EFFECT OF PLANE OF NUTRITION OF BEEF COWS ON DEPLETION OF LIVER VITAMIN A DURING GESTATION AND ON CAROTENE REQUIREMENTS DURING LACTATION

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A RECENT survey conducted by the American National Cattlemen's Association (Ensminger *et al.*, 1955) reveals that many cattlemen consider vitamin A deficiency to be outranked in importance only by pasture bloat as a nutritional problem. Cattlemen in the Southwest frequently attribute livestock losses to vitamin A deficiency, particularly when low-quality roughages are fed during severe drouths, or during winter months. Under these feeding conditions, lack of dietary carotene is often complicated by deficiencies of other nutrients, particularly protein and energy. Research by Giulbert and Hart (1935) showed that beef cattle on sub-maintenance rations utilize liver vitamin A less rapidly than those on above-maintenance and otherwise complete rations. Only a meager amount of data is available on the effect of plane of nutrition of beef cattle on vitamin A utilization.

The results reported herein were taken from part of an extensive series of experiments on the vitamin A needs of beef cattle. The objectives of the study were to test the possible effect of low levels of nutrient intake on the depletion of liver vitamin A stores of beef cows during gestation, and on carotene requirements during early lactation.

Experimental Procedures

Experiment 1—1954

Twenty-four Hereford cows due to calve in April and May were selected from the college herd and a neighboring commercial herd in November, 1953. The cows were from 2.5 to 3.5 years of age. The experiment was essentially a completely randomized one, with a factorial arrangement of the treatments (rations). As shown in table 1, the rations throughout the experiment were designed to provide two levels of energy-and-protein intake, designated as "low" and "adequate". A carotene-deficient ration was used during the gestation phase. The

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cows were assigned at random to one of the two levels of feeding on the basis of initial liver vitamin A stores. At parturition, cows on these two rations were subdivided in order to provide two levels of carotene intake within each feeding regimen during the first three months of lactation. At calving, the first cow on the low level of feeding was as-

TABLE 1. SUPPLEMENTAL RATIONS FED AND MEAN WEIGHT DATA ON COWS AND THEIR CALVES IN EXPERIMENTS I AND II

Level of feeding[a]	Low		Adequate	
Lot number	I	II	III	IV
Gestation phase				
Concentrates fed, lb.				
Cottonseed meal	1.0	1.0	2.5	2.5
Rolled milo			1.0	1.0
Weights, lb.				
Initial	736	751	754	746
Loss to parturition	116	129	63	44
Lactation phase				
Concentrates fed, lb.				
Cottonseed meal	1.5	1.5	3.0	3.0
Rolled milo	2.0	2.0	4.0	4.0
Supplemental carotene, mg.				
Daily allowance				
Per head	27–30	126–150	27–30	126–150
Per 100 lb. body weight	4.4–4.5	19.5–24.0	3.7–4.1	17.2–20.8
Weight gain during lactation, lb.	31	32	78	58
Calves				
Birth weight, lb.	58	56	65	64
Gain to 12 weeks of age, lb.	69	67	88	95
Death loss	2	2	2	0

[a] Roughage was fed *ad libitum* throughout the trials and consisted of weathered range grass baled in November and December. In addition each cow received 2 lb. of dried beet pulp during the lactation phase.

signed to Lot I, the next to Lot II, etc. This procedure was used in allotting all cows to each level of carotene supplementation.

The daily allowances of supplemental concentrate and carotene per cow during lactation are shown in table 1. The roughage fed to all lots during the experiment consisted of weathered range-grass cut in early December and found to be essentially devoid of carotene. In addition, the cows had access to a mineral mixture composed of two parts salt and one part steamed bone meal. The ration for Lots I and II (low level) was deficient in both digestible protein and total digestible nutrients (TDN). The ration fed to Lots III and IV (adequate level)

was calculated to meet the recommendations of the National Research Council (1950). A mixture of oats, milo and cottonseed meal was available in a creep to calves of all lots.

Liver biopsy samples were collected at the beginning of the experiment, using the technique of Whitehair *et al.* (1952). Liver samples were also obtained from the cows immediately after parturition and after 12 weeks of lactation; and from the calves at 12 weeks of age. The cows were weighed and blood samples were taken at the initiation of the study and at approximately monthly intervals throughout gestation. At parturition and at 2, 6, and 12 weeks post partum, the cows and calves were weighed and blood and milk samples from the cows and blood samples from the calves were obtained. Supplemental carotene prepared from alfalfa [2] was provided during lactation by means of a crude carotene concentrate which contained approximately 5 mg. of carotene per gm. The concentrate was mixed with cottonseed meal and fed twice weekly. Carotene and vitamin A were determined in liver samples according to the method of Gallup and Hoefer (1946), in plasma according to the method of Kimble (1939) and in milk by the method of Lesher *et al.* (1945).

Experiment II—1955

Essentially the same procedure was followed in Experiment II as in Experiment I. All cows used in this trial were two-year-olds from the college herd; they had calved the previous spring. The source of supplemental carotene was a carrot concentrate in soybean oil [3] which was given by capsule twice weekly at a level equivalent to 27 mg. per head per day for Lots I and III, and 126 mg. for Lots II and IV.

Results

Level of Feeding

The weight data exhibited the same trend each year, therefore the results of the two experiments were combined and summarized in table 1.

The roughage fed in both experiments was of very poor quality, containing weeds and stemmy material which the cattle did not eat readily. In both trials, the cows were thin at the beginning of the experiment, as reflected in the initial weight data obtained when the cows were 2 to 4 months pregnant. After calving, the cows on the low level of feeding (Lots I and II) had lost approximately 17% of their initial

[2] Supplied by the Chlorophyll Chemical Corp., McAllen, Texas.
[3] Supplied by Nutritional Research Associates, South Whitley, Indiana.

body weight, whereas cows on the adequate level lost approximately 8% of their initial weight. The low feed intake of Lots I and II was reflected in lighter birth weights of their calves as compared to calves from cows on the adequate level.

At birth, calves from cows on the adequate level appeared to be somewhat stronger than calves in the other lots. No death loss occurred at parturition in either experiment, although one calf (Experiment I, Lot III) was lost shortly after delivery. A calf was placed on this cow to permit collection of lactation data. During the first year there was one case of prolapsed uterus and three cases of retained placenta at calving among the cows on the low level of feeding, whereas there was only one case of retained placenta in the other group. In the second year there were two cases of retained placenta among the cows on each level of feeding.

During the lactation phase, the cows on the low level of feeding gained about 31 lb. However, judging by the weight and appearance of their calves, their rations were not adequate for optimum milk production. They were in very poor condition and had not shed their winter hair completely by the end of the trials in August. Cows on the adequate level gained 58 to 78 lb. during lactation, shed their winter hair, and were in good flesh at the termination of the experiments.

Two calves died in each of Lots I, II and III in Experiment I. Although the exact cause of death was not determined, the apparent cause in Lots I and II was a combination of avitaminosis A, secondary infections and malnutrition; in Lot III malnutrition was less a factor and death appeared to be due to secondary respiratory infections and avitaminosis A. In both experiments diarrhea was a problem to some extent among all calves, although more so in Lots I, II and III. The second year, the addition of chlortetracycline (as Aurofac) to the creep feed helped alleviate the severity of diarrhea among the calves in all lots. In each experiment the general condition of the calves in Lots I and II was good until about one month of age, at which time they began to show signs of undernourishment, although they readily ate concentrates supplied in a creep. In contrast, the calves in the other lots were more uniform and thrifty in appearance. In each experiment, typical vitamin A deficiency symptoms such as diarrhea, excess lacrimation, xeropthalmia and exopthalmos were observed in some calves of all lots toward the end of the experimental period. Although they were observed at an earlier age in Lots I and II, the number and severity of cases did not appear to be related to the rations given their dams.

Blood Data

The blood data of Experiment I (table 2) show that at the initiation of the study the cows were in an adequate state of vitamin A nutrition. Depletion of blood carotene occurred rapidly, whereas vitamin A declined at a slower rate. Plasma carotene and vitamin A in late gestation and at parturition were at levels considered indicative of vitamin A

TABLE 2. MEAN PLASMA CAROTENE AND VITAMIN A OF COWS DURING GESTATION AND LACTATION

(mcg. %)

Item	Gestation		Parturition	Lactation	
	Nov.	Feb.	(April & May)	6 weeks	12 weeks
	Experiment 1—1954				
Plasma carotene					
Lot I	132±36	28± 5	17± 9	34±16	26±10
II	116±24	28± 8	23±14	73±29	62± 9
III	144±61	25± 6	25±17	18±11	28±10
IV	159±74	33±11	21±10	74±58	67±20
Plasma vitamin A					
Lot I	30±3	16±2	17±5	18±2	15±3
II	32±4	18±4	17±8	22±5	22±7
III	37±6	19±3	14±6	15±4	16±4
IV	35±5	21±2	14±5	19±8	20±3
	Experiment II—1955				
Plasma carotene					
Lot I	362±127	41± 8	66± 18	76±20	74±12
II	326± 59	32±16	57± 33	186±16	193±50
III	390±110	32± 3	58± 19	92±22	94±21
IV	380± 68	30± 5	154±187[a]	247±76	267±62
Plasma vitamin A					
Lot I	37±4	22±6	15±3	22±4	20±4
II	36±2	22±2	13±1	22±4	26±4
III	28±6	23±3	15±4	23±5	19±5
IV	36±6	23±3	16±4	27±3	24±7

[a] High carotene level due to two cows that got out of the small trap to which they were confined during the winter. While out for several days, they had access to green pasture.

deficiency in mature cattle (Madsen and Davis, 1949). However, no clinical symptoms of avitaminosis A were observed in the cows in this experiment. There was no apparent affect on blood vitamin A or carotene related to the differences in level of feeding (protein and energy) during the gestation phase. Supplementation during lactation with 30 mg. of carotene per day (Lots I and III) was sufficient to maintain, or increase slightly, the plasma vitamin A and carotene of the cows. The

150 mg. level (Lots II and IV), when compared with 30 mg., produced a highly significant increase in plasma carotene (P=.01) and a significant increase in plasma vitamin A (P=.05) at 12 weeks post partum.

Blood data from Experiment II (table 2) followed the same pattern during gestation as in the previous year, with no apparent effect due to level of feeding. Toward the end of the gestation phase the cows had

TABLE 3. MEAN PLASMA CAROTENE AND VITAMIN A OF CALVES AT INTERVALS FROM BIRTH TO TWELVE WEEKS OF AGE

(mcg. %)

Item	Birth	2 weeks	6 weeks	12 weeks
		Experiment I—1954[a]		
Plasma carotene				
Lot I	4.3±5.5	7.8±6.7	5.2±6.9	14.7± 4.5
II	4.2±2.5	3.2±4.0	6.5±2.2	12.6± 4.3
III	2.0±3.4	4.2±3.7	2.0±1.8	11.7± 3.2
IV	2.8±3.6	7.6±4.7	5.8±5.8	16.9±10.0
Plasma vitamin A				
Lot I	9.6±5.2	11.6±6.0	10.1±5.5	8.9±0.5
II	8.7±2.3	9.2±5.4	7.6±2.1	8.0±1.9
III	7.9±2.8	10.3±5.5	7.2±1.7	8.0±2.4
IV	6.2±1.4	11.2±5.4	9.1±2.2	7.6±2.5
		Experiment II—1955		
Plasma carotene				
Lot I	0.0	8.0±2.8	9.8±1.3	7.9±2.2
II	0.0	6.3±3.5	11.4±3.5	6.4±3.6
III	2.7±2.7	4.7±1.9	11.3±1.9	7.5±2.6
IV	1.5±2.4	10.2±5.1	15.3±2.6	8.0±4.9
Plasma vitamin A				
Lot I	6.5±3.1	10.3±3.4	10.2±2.5	2.6±1.4
II	7.4±0.9	11.3±3.3	9.7±2.9	2.2±2.1
III	6.4±0.9	8.0±1.3	8.5±3.5	2.9±1.2
IV	8.1±1.5	10.3±1.7	10.6±2.4	4.0±2.1

[a] Two calves died in each of Lots I, II and III between six and ten weeks of age.

access to a small amount of grass in the paddock in which they were kept during the winter such that it resulted in some increase in blood carotene at parturition. Supplementation with 27 mg. of carotene during the lactation phase (Lots I and III) was sufficient to increase slightly the plasma vitamin A at both levels of feeding. Supplementation with 126 mg. produced a significant increase (P=.05) in plasma vitamin A and a highly significant increase in plasma carotene (P=.01) when compared with the lots receiving 27 mg. of carotene.

Among the calves there were no significant differences in blood constituents studied (table 3) due to treatments applied to their dams in either year. In Experiment I blood carotene declined between two and six weeks, then increased at 12 weeks of age. Possibly this was due to consumption by the calves of a part of the carotene concentrate intended for the cows. In Experiment II, when carotene was given to the cows by capsule, blood carotene levels in the calves increased between two and six weeks and then declined at 12 weeks. Blood vitamin A levels in the two-and-six-week samples were comparable in each experiment. In Experiment I, the 12-week samples from the calves were indicative of a borderline deficiency in all lots; in Experiment II, they were indicative of a definite deficiency in all lots (Boyer *et al.*, 1942; Moore, 1939).

Liver Data

The initial liver vitamin A concentration of the cows ranged from 119 to 587 mg. per gm. of dry matter in Experiment I and from 168 to 804 mcg. per gm. in Experiment II. Examination of data in table 4 reveals no consistent effect on depletion of liver vitamin A associated with levels of feeding in either experiment. In the gestation phase of Experiment I, the depletion of liver vitamin A was the same in both levels of feeding. However, one cow in the Low level group was depleted in liver vitamin A from an initial value of 587 mcg. to 54 mcg. at parturition, a much more rapid rate of depletion than occurred in other cows having comparable initial liver reserves. If data from this cow were omitted, the rate of depletion of liver vitamin A would be greater at the adequate level than at the low level of feeding. In the gestation phase of Experiment II, depletion of liver vitamin A was greater in the cows on the adequate level of feeding.

During the lactation phase, depletion of the liver in vitamin A continued in all lots in both experiments but was greater in the cows receiving 27–30 mg. of carotene (Lots I and III) than in those receiving 126–150 mg. (Lots II and IV). The results indicate that carotene intake, even at the higher level of supplementation, was hardly adequate to maintain liver reserves. The inconsistent effect of level of feeding (nutrition) on depletion of liver reserves of vitamin A is shown in a comparison of the mean for Lot I and II with that for Lot III and IV in each experiment. In Experiment I the mean loss during lactation for the low and adequate feeding groups was 58 and 73 mcg., respectively; in Experiment II it was 42 and 33 mcg., respectively.

In neither year did the liver vitamin A of the calves reflect the carotene supplementation of their dams. In both years, vitamin A in the liver of calves at 12 weeks of age was indicative of avitaminosis A, ranging from 1.5 to 3.6 mcg. per gm. of dry matter.

TABLE 4. MEAN VITAMIN A CONCENTRATION OF LIVER BIOPSY SAMPLES TAKEN AT INTERVALS THROUGHOUT THE EXPERIMENTAL PERIOD

(mcg./gm. dry matter)

Level of feeding	Gestation phase			Lactation phase			
	Initial[a]	Parturition	Loss to parturition	Parturition	12 weeks post partum	Loss during lactation	
Experiment I—1954							
Low	312	84	228	Lot I[b]	138	64	74
				Lot II[b]	58	16	42
				Mean	98	40	58
							86
Adequate	311	82	229	Lot III[b]	113	17	96
				Lot IV	74	21	53
				Mean	92	19	73
							49
Experiment II—1955							
Low	434	172	262	Lot I	170	106	64
				Lot II	173	153	20
				Mean	172	130	42
							55
Adequate	436	108	328	Lot III	116	70	46
				Lot IV	101	81	20
				Mean	108	76	33
							20

[a] Initial samples were taken five to seven months prepartum.

[b] These means do not include the cows whose calves failed to survive for the 12 week period of lactation.

Discussion.

Although liver data from these experiments provide no conclusive proof as to the affect of a low plane of nutrition in reducing liver vitamin A depletion, certainly the low level of feeding did not consistently increase the rate of depletion. Since dietary vitamin A is required in proportion to body weight, it seems logical that the greater body weight of cows on the adequate level might actually result in more rapid depletion of liver reserves.

The National Research Council (1950) recommends that beef cows receive 6 mg. of carotene per 100 lb. of body weight during gestation and 30 mg. per 100 lb. during lactation. The experiments reported herein agree with previous work at this station (Baker *et al.*, 1954; Church *et al.*, 1955) in that beef cows can reproduce successfully when fed carotene deficient rations during all or part of the gestation phase, even when liver reserves of vitamin A were quite low. Further, Baker *et al.* (1954) found that 300 mg. of carotene (in excess of 30 mg. per 100 lb. body weight) were enough to prevent clinical symptoms in calves at 3 months of age and prevent a severe depletion of liver reserves in the cows. In the experiments reported herein, the carotene supplements were given at levels varying from approximately 3.7 mg. to 24.0 mg. per 100 lb. of body weight (table 1) using an average of the parturition and 12-weeks post partum weights. In Experiment II, although average liver vitamin A values decreased during lactation, individual values increased or remained essentially constant for several cows receiving from 17 to 22 mg. per 100 lb.

In Experiment II, milk yield after 12 weeks of lactation was estimated by obtaining 12-hour samples from each cow. Estimated daily milk production was 1.025 and 1.620 liters for low and adequate level cows, respectively. Estimated daily output of milk vitamin A was 27, 27, 14 and 20 mcg., and of carotene, 33, 43, 46 and 67 mcg. for Lots I, II, III and IV, respectively. Although these data indicate a minor effect due to treatment, the vitamin A potency of all milk was extremely low.

Data reported by Wise *et al.* (1948) showed that calves receiving milk from cows getting roughage high in carotene had blood values at four and six weeks of age which were indicative of sub-marginal deficiencies, and that blood levels did not increase until hay consumption increased. This may indicate that milk alone will not ordinarily provide sufficient vitamin A to maintain calves in an adequate state of vitamin A nutrition past one to two months of age.

Summary

Two experiments were conducted with grade Hereford cows, divided into two groups and maintained at low or adequate levels of nutrition (protein and energy) during the last 5 to 7 months of gestation and the first 12 weeks of lactation to determine the effect of nutritive plane on vitamin A metabolism. During the gestation phase, both groups were fed low carotene rations. At parturition, one-half of each group received

27–30 mg. of carotene per head daily, while the remaining cows received 126–150 mg.

The low plane of nutrition, as compared to the adequate level, had no apparent effect on vitamin A depletion during gestation in the first experiment, but did delay depletion in the second experiment. During lactation, the low plane of nutrition resulted in less liver depletion in one of two experiments. Blood levels of carotene and vitamin A in the cows and their calves were not significantly affected. The low plane of feeding had an adverse effect on the nutrition of the calves, resulting in less gain in weight and apparent malnourishment.

Carotene supplementation during lactation, as practiced in these experiments, failed to promote vitamin A storage in the liver of the cows irrespective of plane of nutrition. The high level of carotene (126 to 150 mg. per day) decreased rate of liver depletion and increased levels of carotene and vitamin A in the plasma; although neither level was sufficient to prevent symptoms of vitamin A deficiency among the calves. Apparently, for the production of healthy calves, range cows on low carotene rations during the latter half of gestation require a daily carotene intake of 20 mg. or more per 100 lb. during subsequent lactation, regardless of plane of nutrition.

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COMPENSATORY GROWTH OF BEEF CATTLE: THE EFFECT OF PROTEIN SUPPLEMENTS

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USUAL recommendations specify that wintering beef cattle should be fed so that continuous growth is maintained. Morrison, (1948) advises feeding calves so that they will gain three fourths to 1 lb. daily when summer grazing conditions are good and a minimum of one half lb. daily with poor summer pasture. While animals do not use their feed as efficiently for the entire growth period with restricted or retarded growth (Guilbert *et al.*, 1944, Johnston *et al.*, 1952), they are not permanently stunted and tend to accelerate their growth rate when adequate feed is again available and approach the body weights of similar non-restricted control animals (Winchester and Howe, 1954; Bohman, 1955).

In Nevada approximately one-half of the land from which crops are harvested produces native grass hay of variable quality. The majority of beef cattle in the state and a large proportion in other western states are wintered almost exclusively on this type of roughage. Previous work (Shipley and Headley, 1948; Bohman, 1955) has shown that the stage of maturity of hay at harvest markedly influences its nutritive value. As the stage of maturity advances, the percentage of both protein and phosphorus decreases rapidly. Hay harvested at an early stage of maturity produced much greater gains than hay harvested later when fed to wintering beef cattle. However, when all animals were placed on the same summer range, the retarded animals grew faster and by fall only small differences existed between the two groups of cattle (Bohman, 1955).

Since the level of protein was borderline or inadequate in the hay harvested at an early stage of maturity and markedly deficient in that harvested later for weanling beef calves, experiments were devised to measure (1) the effects of protein as a supplement to native grass hay harvested at two stages of maturity for wintering weanling beef cattle, and (2) the effect of these winter treatments upon subsequent summer gains.

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Experimental Procedure

This experiment was conducted during the winters of 1953–54 and 1954–55 and the following summers at the Knoll Creek Experimental Range Station in Northeast Elko County. This area and range practices have been described previously (Bohman, 1955). The early-cut hay was harvested approximately July 15 and the late-cut hay August 25. Weanling grade Hereford beef cattle were matched according to weight and sex and allotted at random to experimental groups in a 2^3 factorial experiment. The experimental treatments were as follows: method of feeding, individual or groups of three; hay maturity, early or late; protein supplement as cottonseed meal or none. In addition other cattle were fed late-cut hay individually and in groups, supplemented with alfalfa

TABLE 1. THE AVERAGE CHEMICAL COMPOSITION OF FEEDS

		Percent of dry matter				
Feed	Percent dry matter	Crude protein	Ether extract	Crude fiber	Ca	P
Early-cut hay	94.1	8.0	2.2	34.4	0.60	0.18
Late-cut hay	94.2	7.1	2.5	33.0	0.83	0.15
Alfalfa	93.2	17.5	2.7	28.7	1.80	0.24
Cottonseed meal	93.9	45.0	5.2	14.3	0.22	1.19

pellets to supply approximately the same amount of protein as contained in the cottonseed meal. During the second year a $2\times2\times3$ factorial design was employed with the above treatments and with alfalfa as the third protein supplement. The chemical composition of the feeds used in this study are given in table 1. Hay was fed according to the appetites of the animals and was continuously available. A mineral mix composed of 50% each of salt and steamed bone meal was supplied free choice. During the summer the cattle grazed as a single group on fenced summer range. The data were orthogonal and amenable to analysis of variance as described by Snedecor (1946). The average initial weight of the cattle was 425 lb. the first year and 364 lb. the second.

Results and Discussion

The response of weanling cattle to the various treatments is summarized in tables 2 and 3. During the first winter animals fed the early-cut hay gained signficantly faster than the cattle fed hay harvested at a later stage of maturity. In addition, the animals that were retarded dur-

TABLE 2. THE EFFECT OF FEEDING METHOD AND HAY MATURITY UPON WINTER AND SUBSEQUENT SUMMER GAINS

Year and treatment	No. of animals compared	Winter (I)					Summer (II)		Year (I & II)	
		Days	Av. daily gains	Av. feed consumed daily (lb.) Hay	CSM	Alfalfa	Days	Av. daily gains	Days	Av. daily gains
			lb.					lb.		lb.
1953–54										
Early-cut hay	12	124	0.46*	9.0	0.5		159	1.00*	283	0.87
Late-cut hay	18(12)	124	0.32(0.25)	9.2(9.6)	0.3(0.5)	1.0(0)	159	1.25(1.19)	283	0.90(0.87)
1954–55										
Early-cut hay	18	105	0.58	7.2	0.3	1.0	142	1.30	247	0.98
Late-cut hay	18	105	0.53	7.6	0.3	1.0	142	1.28	247	0.96
1953–54										
Individuals	15	124	0.40	9.5	0.4	0.5	159	1.21*	283	0.85
Groups	15	124	0.35	8.7	0.4	0.5	159	1.09	283	0.77
1954–55										
Individuals	18	105	0.52	7.2	0.3	1.0	142	1.38**	247	1.01
Groups	18	105	0.59	7.5	0.3	1.0	142	1.20	247	0.93

Figures in parenthesis for 1953–54 equal the values obtained without the alfalfa supplemented group.
* Difference is significant at the 5% level.
** Difference is significant at the 1% level.

TABLE 3. THE EFFECT OF PROTEIN SUPPLEMENTS UPON WINTER AND SUBSEQUENT SUMMER GAINS

Year and supplement	No. of animals compared	Days	Winter (I)			Summer (II)		Year (I & II)	
			Av. daily gains	Feed consumed daily		Days	Av. daily gains	Days	Av. daily gains
				Hay	CSM or alfalfa				
			lb.	lb.	lb.		lb.		lb.
1953–54									
None	12	124	0.12**	9.2	0	159	1.14	283	0.69**
Cottonseed meal	12	124	0.59	9.4	1.0	159	1.05	283	0.85
Alfalfa	6	124	0.46	8.6	3.0	159	1.38**	283	0.98
1954–55									
None	12	105	0.24**	8.0	0	142	1.36**	247	0.88**
Cottonseed meal	12	105	0.77	7.7	1.0	142	1.20	247	1.01
Alfalfa	12	105	0.60	6.6	3.0	142	1.30	247	1.03
Average or total									
None	24	115	0.18**	8.6	0	150	1.25	265	0.78**
Cottonseed meal	24	115	0.68	8.6	1.0	150	1.12	265	0.93
Alfalfa	18	115	0.53	7.6	3.0	150	1.33**	265	1.00

** Difference is significant at the 1% level.

ing the winter gained more the following summer. At the end of the year, both groups of cattle had gained approximately the same. These data are in agreement with previous work from this station (Bohman, 1955) although the differences reported in this paper are not as great as those noted earlier. The chemical composition of the forages was not as divergent as in earlier trials and the differences may have been masked by feeding supplements to part of the cattle. An examination of the data for the second year shows that the animals fed hay harvested at

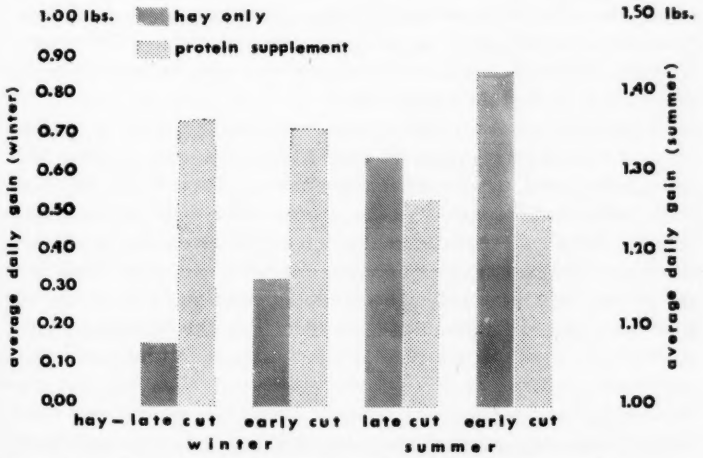

Figure 1. The effect of protein supplements and hay maturity on the growth of calves (1954–55).

either stage of maturity gained equally well. Although the response of the cattle on the two treatments was not statistically different, there was a significant interaction between the stage of hay maturity and the protein supplements. Approximately equal gains were obtained when the animals were fed either late- or early-cut hay supplemented with either alfalfa or cottonseed meal. However, the cattle fed early-cut hay without supplements gained twice as rapidly as similar cattle fed the more mature roughage (figure 1). During the summer a similar trend was noted. The cattle supplemented during the winter gained approximately the same the following summer regardless of the type of roughage consumed. The type of hay influenced the summer gains of the cattle that were not fed supplements. Again, this interaction was sig-

nificant. Similar results were obtained for the entire year. The data, except for the second summer, confirm the results of previous years and also indicate that protein supplements tend to mask the differences in the nutritive value of native meadow hay harvested at two stages of maturity.

Contrary to data presented by Kidwell *et al.* (1954), the method of feeding had no effect upon the growth of wintering beef cattle. Cattle gained equally as rapid during the winter whether they were individually or group fed. The following summer when all animals were ranged together, the cattle fed individually during the winter gained significantly faster than the animals fed in groups the preceding winter. The reasons for these differences are not immediately apparent. Differences in the amount of fattening might be the cause.

Weanling cattle fed either alfalfa or cottonseed meal as protein supplements gained significantly faster during the winter period than non-supplemented animals fed native grass hay harvested at either an early or late stage of maturity. The observed differences in rate of gain between the animals fed cottonseed meal and alfalfa was not statistically significant. The following summer the retarded cattle grew faster than the animals supplemented with cottonseed meal. In one of the two years they gained signiñcantly more than both supplemented groups. However, for the entire year the cattle supplemented with either protein source produced significantly greater gains than the animals that were fed only hay during the winter. The cattle fed either protein source consumed more total feed than those fed only hay but, not a sufficiently greater quantity to account for the difference in growth.

When the protein intake was restricted during the winter so that only the maintenance requirements were met (0.09 lb. daily gain for the cattle fed late-cut hay without supplements) or with slight growth permitted (0.27 lb. daily gain for the cattle fed early-cut forage) permanent stunting did not occur. The retarded cattle gained equally as fast or faster during the following summer as animals that had not been restricted in growth. Cattle supplemented with cottonseed meal had gained on the average of 57 lb. more than the controls at the end of the winter feeding period but the difference in gain was only 39 lb. at the end of the summer season. The cattle thus tended to compensate for poor winter gains by accelerated growth the following summer. This response is similar to that noted previously when hays harvested at different stages of maturity were fed (Bohman, 1955). These results are also confirmed by Nelson *et al.* (1954) who found that winter gains

of weanling heifers fed prairie hay were directly related to the protein content of the supplement. In addition, heifers that gained the least during the winter made the most rapid growth the following summer. Average yearly gains of these animals increased with the higher level of protein in the winter supplements. The protein content of their supplement was varied by the amount of cottonseed meal that was included in the pellet. Alfalfa affected the growth of wintering cattle in the same manner as cottonseed meal. However, during the summer alfalfa appeared to have a residual effect and promoted gains exceeding those of cottonseed meal ($P<0.01$), and slightly more than the non-supplemented groups. Although the observed gains for the entire year were greatest when alfalfa was fed as a supplement, they were not significantly more than the gains of the groups that received cottonseed meal. The cattle supplemented with alfalfa consumed on the average one pound less grass hay daily than the other groups, but more total feed. Beeson and Perry (1952) found that 1 to 2 lb. of alfalfa meal stimulated the growth of wintering steers. They postulated that alfalfa contained some nutritional factor or factors which stimulated growth of beef cattle beyond the extra energy that it furnished. Baker *et al.* (1947) also found that dehydrated alfalfa meal would stimulate the rate of gain of steers fed corn cobs and corn silage as a roughage source in a fattening ration. Alfalfa ash (Swift *et al.*, 1951; Burroughs *et al.*, 1950) increased the digestibility of the dry matter of a ration containing a large proportion of corn cobs. Perhaps one or more of the factors were stored by the animals which in turn stimulated their summer growth. Additional studies are being conducted to investigate several possible factors.

Summary

Wintering beef calves fed hay harvested at an early stage of maturity gained significantly more than animals fed hay harvested later. During the following summer, the retarded cattle accelerated their growth rate and were as heavy the following fall as the non-restricted group. The feeding of protein supplements tended to mask the differences in nutritive value of hays harvested at different stages of maturity. Cattle that had been individually-fed during the winter gained faster the following summer than similar cattle group-fed during the winter. Protein supplements markedly increased the winter gains of the beef calves. However, the subsequent summer gains depended upon the type of protein supplement fed the preceding winter. Alfalfa stimulated the greatest summer gains; cottonseed meal the least; and the control ani-

mals without supplements were intermediate. With the exception of the alfalfa treatments, there was less difference in total gains between the control animals and the supplemented cattle at the end of the summer grazing season than at the end of the wintering period. All cattle that received protein supplements during the winter were heavier than the non-supplemented animals the following fall.

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THE EFFECT OF WINTERING PLANE OF NUTRITION ON SUBSEQUENT GAINS OF BEEF YEARLING STEERS ON IRRIGATED PASTURES [1]

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THE use of irrigated pastures for beef cattle has increased tremendously during recent years. For example, in four of the long-established irrigated areas in Washington, the increase in acreage of irrigated pastures from 1940 to 1954 was 33% (USBR, 1940, 1954; USDI, 1940, 1954). The trend has been to the use of yearlings, because older animals are likely to be excessively heavy at the time of slaughter.

Yearlings on irrigated pastures are not usually given additional feed except late in the grazing season. However, supplemental feeding, even late in the season, is not the general practice. Good irrigated pastures will provide an abundance of nutritious feed for yearlings and will give a season-long average daily gain of nearly 2.5 lb. per day (Heinemann and Van Keuren, 1955). Feeding of a concentrate would probably add little, if any, to the average daily gain except during the last one-third of the grazing season.

It is generally conceded that calves must be fed sparingly in the winter, so as to gain from 50 to 75 lb. during the winter or not more than about 0.50 to 1.00 lb. per day, in order to obtain the best results from non-irrigated pastures (Black, 1927; Connell *et al.*, 1948; Kincaid *et al.*, 1945; Mott *et al.*, 1953; Potter and Withycombe, 1926; Ruby *et al.*, 1948; Sheets, 1921). Moreover, Mott *et al.* (1953) have shown that the yield of beef per acre is reduced when non-irrigated pastures are grazed by steers wintered at a high level of nutrition. Kincaid *et al.* (1945) and Potter and Withycomb (1926) have presented results to indicate that for every pound calves gain during the wintering period, they will make from 0.42 to 0.58 lb. less gain during the grazing period. Beeson *et al.* (1949) indicate a reduction of 0.2 to 0.5 lb. when bluegrass is the pasture, and McCampbell (1922) showed a reduction ranging from 0.2 to 0.6 lb. in pasture gain for each pound of winter gain. However, Ruby *et al.* (1948) have found that increased winter gains resulted in increased total gains despite the fact that a negative

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correlation existed between winter gain and summer gain. In their trials, as the average winter gain of the calf increased by 1 lb., the subsequent summer gain decreased by 0.22 lb. Miller and Morrison (1953) also found that the addition of 2 lb. of corn to the wintering ration fed to heavy steer calves resulted in greater gain and more fleshing during the winter period, less gain during a 100-day pasture season, and slightly more gain for the entire period. Cost per 100-lb. gain was lower for calves wintered without grain, but they had a slightly lower selling price per pound.

Experimental

These trials were conducted at the Irrigation Experiment Station, Prosser, Washington.

The experiment was designed to determine the effects of three wintering rates of gain by beef calves on their subsequent performance on good irrigated pastures in an attempt to produce U. S. Good grade long yearling slaughter cattle without supplemental feeding or feedlot finishing.

Weanling Hereford calves, grading Good and weighing about 518 lb. were obtained from a range operator and placed on the three wintering level treatments on November 28. They were assigned at random to six lots of 10 calves each. Two lots were fed at each level of nutrition, namely, to produce an average daily gain of about (1) 0.33 lb., (2) 1.0 lb., and (3) 1.25 lb. Different ratios of alfalfa hay and corn silage were fed to the calves on the first two treatments and dried molasses beet pulp, in addition, was fed to those on the third treatment.

Following the 155-day wintering period, the cattle were placed on six kinds of irrigated pastures on May 3. Each pasture was replicated three times. A fourth replicate of each served as a holding pasture. A random assignment of the yearlings to pastures was made from within each wintering treatment. Thus, each pasture (40,000 sq. ft. per pasture) had assigned to it initially three animals—one from each wintering treatment.

The six kinds of pastures, established the previous year, were (1) Orchardgrass-Ladino clover, (2) Orchardgrass-alfalfa, (3) Orchardgrass, (4) Tall fescue-Ladino clover, (5) Tall fescue-alfalfa, and (6) Tall fescue. Each pasture was subdivided into four equal-sized areas, using electric fences, for rotational grazing. Irrigation water was applied at times and rates recommended for the particular pastures when grown in this area. Thus, water was not a limiting factor. Usually water

applications were made immediately following grazing, but never while the animals were on a given area.

Phosphorus and nitrogen fertilizers were applied at annual rates of 40 lb. of P_2O_5 and 200 lb. of available nitrogen per acre to the grasses. The same rate of P_2O_5 was applied to the grass-legume pastures, but only 125 lb. of available nitrogen was applied to these pastures. All of the phosphate was applied at one time. The nitrogen was applied in three equal quantities about mid-March, mid-June and early August.

Lot weighings of the calves were made at 30-day intervals during the wintering period, and individual weights were taken every 22 days on

TABLE 1. WEIGHT INCREASES AND FEED EFFICIENCY

Wintering level	Av. winter gain, lb.		Av. feed consumption per calf, lb.					
			Corn silage		Alfalfa hay		Dried beet pulp[a]	
	Daily	Total	Total	Per lb gain	Total	Per lb. gain	Total	Per lb. gain
High	1.29	200	1669	8.3	1556	7.8	120	0.6
Medium	1.01	157	1679	10.7	1330	8.5	None	
Low	0.33	51	2170	42.5	690	13.5	None	

[a] Dried molasses beet pulp was fed only during the last 60 days of the wintering period.

pasture. Individual weighings were also made (1) on two successive days at the beginning of the wintering period, (2) at the end of the wintering period (these weights were also the initial pasture weights), (3) at the end of the grazing season, and (4) when the animals were marketed either off pasture or following a short grain feeding period.

Following the grazing season, the cattle were fed ear corn meal and alfalfa hay until they graded U. S. Good. The pastures were sampled just before being grazed to provide information on the yield of forage and the percentage of legume.

Results and Discussion

Wintering period

Weight increases and feed efficiency data for the 155-day winter feeding period, by treatments, are shown in table 1.

Paired comparisons of the wintering level means for daily gain were made using the "t" test based upon within level variation. The results of this are summarized in table 2, and show that the low level of feeding produced gains significantly below either of the other levels.

TABLE 2. MEAN DIFFERENCES AND t TESTS FOR WINTERING LEVEL COMPARISONS

Wintering level comparison	Mean difference	Observed t	d.f.	P
High vs. medium	0.28	0.6903	34	>0.4
High vs. low	0.96	2.8863	34	<0.01
Medium vs. low	0.68	2.5185	34	<0.05

The calves wintered at the low level lost condition. Their gains cost about 75% more than the per-pound buying price of 17.65 cents. The calves on the medium and high levels gained in condition and at feed costs of 20 and 25%, respectively, below the buying price. The feed costs per day were inversely related to the feed costs per lb. of gain. Feed costs per animal-day and per pound gain, are shown in table 3.

Grazing period

The gains made by the cattle during the 155-day grazing period were used to measure the effect of the wintering treatments on average daily gains on the six kinds of irrigated pastures. Gain data are shown in table 4.

Analysis of variance showed that a significantly greater ($P<0.05$) average daily gain resulted from grazing grass-legume mixtures over straight grasses. Also, pasture gains of steers wintered at the low level were significantly higher ($P<0.01$) than those of steers wintered at the high and medium levels (table 4).

A significant negative correlation ($P<0.01$) of -0.64 was found between winter gains and subsequent gains during the grazing season. The regression value was -0.63 lb. of summer gain per lb. of winter gain ($P<0.01$), and $s_{y.x}$ was 0.3640. An analysis of covariance revealed no significant differences among the regression coefficients within the wintering levels.

Regardless of kind of pasture or wintering treatment, the cattle had

TABLE 3. FEED COST FOR WINTER GAINS

Winter level	Feed costs, cents[a]	
	Per animal-day	Per pound gain
High	16.96	13.15
Medium	13.99	13.85
Low	11.47	34.75

[a] Based on following feed prices per ton (dollars), alfalfa hay 20, corn silage 10, and dried molasses beet pulp 40.

TABLE 4. EFFECTS OF WINTER GAINS ON PERFORMANCE OF STEERS ON SIX KINDS OF PASTURE

Wintering level	Average daily gains, lb.			
	High	Medium	Low	Average
Kind of pasture				
Orchardgrass-Ladino clover	2.38	2.05	2.84	2.42
Orchardgrass-alfalfa	1.68	2.19	2.37	2.09
Orchardgrass	1.54	1.39	1.91	1.62
Tall fescue-Ladino clover	2.27	1.77	2.68	2.24
Tall fescue-alfalfa	2.09	2.01	2.53	2.21
Tall fescue	1.39	2.06	2.39	1.94
Average	1.89	1.91	2.45	2.09

	Mean difference in lb.	Significance
Legume vs. no legume	0.46	$P<0.05$
Low vs. high and medium winter levels	0.55	$P<0.01$

not attained sufficient finish to grade U. S. Good at the end of the grazing season; a grain feeding period of about 54 days was necessary. All animals were fed to high Good grade. There was no significant difference in average daily gain, length of feeding period or market weight due to the three wintering tratments. Average values are shown in table 5. Animals from all treatments sold at the same price, although the packer-buyer had the privilege of a sort.

Summary

Weaned beef calves wintered for 155 days at three levels of nutrition were subsequently placed on six kinds of irrigated pastures. As yearlings, the cattle were assigned at random from each of the wintering treatment groups to each of the pastures.

TABLE 5. FEEDLOT PERFORMANCE FOLLOWING THE GRAZING SEASON

Wintering level	Av.daily gain	Weight at end of pasture season	Av. length of feeding period to attain "Good" grade	Av. weight when "Good" grade attained
	lb.		days	lb.
High	2.23	977	53.8	1097
Medium	2.23	935	56.6	1061
Low	1.96	944	50.6	1043

Average daily gains by calves on the high, medium, and low wintering treatments were 1.29, 1.01, and 0.33 lb., respectively, at per-pound costs for feed of 13.15, 13.85, and 34.75 cents. There was no significant difference between the average daily gains made by the calves on the high and medium treatments. A significant difference was noted between the gains of the low treatment calves and those on each of the other two wintering treatments.

Cattle grazing the grass-legume mixtures gained significantly faster than those grazing the grasses. There was also a significant difference between the pasture gains of the steers wintered at the low level and those wintered at medium and high levels. Average daily gains on pasture were 1.89, 1.91, and 2.45 lb. by the steers wintered at the high, medium, and low levels, respectively. A significant negative correlation was found between winter gains and subsequent pasture gains.

Wintering treatment had no significant effect on feedlot performance of the cattle following the grazing season.

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GROWTH PERFORMANCE AND BLOOD AND LIVER COPPER VALUES IN HEREFORD CALVES OFFERED CERTAIN MINERAL ELEMENTS FREE CHOICE [1]

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IN the Oregon Coastal Region, cattle have periodically developed symptoms suggesting minor element nutritional deficiencies such as late shedding, dullness and fading of haircoat in Hereford cattle, thin persistent watery scours, emaciation, depression of appetite, and occasional delayed estrus. Improvement has often been noted following administration of copper and cobalt in solution by drench, or in pellet form.

Forage analyses for this region show a mean copper value of 7.0 ppm and a mean molybdenum value of 3.5 ppm (Dent, 1953). Cattle blood copper values for the Oregon Coastal Region indicate a marginal copper level (Dent and Howell, 1954). Fifty-four animals, 9 to 72 months of age, had a mean blood plasma copper value of 0.574 ppm. Four animals sacrificed at 16 to 20 months of age had liver copper values of 4.0, 16.8, 2.6, and 21.4 ppm.

Some workers have suggested that animals will correct their own dietary deficiencies if the proper minerals are provided free choice (Becker, 1925). The present experiment was designed to seek information on this subject, to correlate blood and liver copper values, and to determine effects of various minerals on feed consumption and the rate and efficiency of gain.

Experimental Procedure

Ten station-reared female Hereford beef cattle calves from 7.5 to 8.5 months of age were used in this trial. Samples of blood, liver tissue and fecal material were taken at intervals during the trial. Blood samples were collected in bottles containing saturated sodium citrate solution (1.25 ml. per 100 ml. blood) and iced until analyzed. Liver

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samples were taken by the method described by Bone (1954) and were placed in previously dried and tared glass-stoppered vessels. Fecal samples were stored in ointment boxes pending laboratory observation. The first biopsy, blood and fecal samples, were taken 17 days after weaning, with additional samplings at 92 and 140 days, and a final sampling approximately six months following termination of the experiment. A 3-week period allowed for recovery and gentling after the first bleeding was followed by a 7-day adjustment period in individual stalls. The calves were then placed on full feed for the subsequent four months. All feed was weighed individually to each animal twice daily. Any refusal was weighed back and a net total consumption calculated for each animal. Grain was fed on top of the silage while hay was placed in one corner of the feed box.

Good quality grass silage prepared with sugar beet molasses was used for roughage. The limited hay fed was station produced, low quality, and composed of approximately one-third early bloom *Lotus major*, one-third orchard grass and one-third various bent species. The concentrate mixture was composed of 300 lb. ground oats, 700 lb. ground barley, 10 lb. urea (42% N), 0.25 lb. vitamin D_2 supplement (containing 2 million I.U. per pound) and 4 gm. of KI. The vitamin D_2 and KI were premixed and all ingredients were well mixed in a commercial mechanical mixer.

Six individual mineral boxes were provided for each animal. Individual mineral preparations were placed randomly in the boxes with each animal receiving minerals in the same random order. The feed box was placed at either end of the mineral box group, depending on the stall construction.

Mineral mixtures offered were composed of the following: (1) dicalcium phosphate (21% P), (2) cobalt and salt (25 lb. salt containing 2.35 gm. $CoCO_3$), (3) steamed bone meal (14% P), (4) salt, (5) magnesium sulfate and salt (25 lb. salt containing 2.5 lb. technical grade $MgSO_4 \cdot 7H_2O$), and (6) copper sulfate and salt (25 lb. salt containing 113.5 gm. $CuSO_4 \cdot 5H_2O$). A high grade vacuum-type salt containing 0.05% $MgCO_3$ was used. Mineralized salts were weighed out in 200-gm. lots and replenished as they were consumed. Control animals received straight salt in each box in lieu of the mineralized salt. At the termination of the trial, leftover salts were dried, weighed back and net consumption figures calculated.

Weather permitting, the animals were allowed to exercise one or two

hours daily in a bare open lot. Individual animal weights were taken at approximately 10-day intervals.

Whole blood and plasma copper values were determined spectrophotometrically using diethyldithiocarbamate (Eden and Green, 1940) as the color developing reagent. Liver analyses followed the same procedure using a 2 gm. wet liver sample which was wet-ashed with nitric, sulfuric and perchloric acids. An aliquot was taken from the liver digest and iron determined spectrophotometrically with 1,10-phenanthroline. Copper, cobalt, and iron in forage, silage and grain were determined spectrophotometrically with sodium diethyldithiocarbamate, nitroso-R-salt, and 1,10-phenanthroline, respectively (Marston *et al.*, 1940) (Parks *et al.*, 1943).

TABLE 1. FEED ANALYSES

	Silage I	Silage II	Hay lotus-grass	Grain mix.
Dry matter, %	26.5	48.4		
Crude protein, %	14.9	10.57	6.55	12.45
Calcium, %	0.43	0.29	0.21	0.12
Phosphorus, %	0.33	0.25	0.18	0.36
Cobalt, ppm	0.37	0.39	0.15	0.17
Copper, ppm	7.4	7.6	4.6	5.7
Iron, ppm	193.0	893.0	77.0	95.0
Molybdenum, ppm	5.8	1.5	2.6	0.8
pH		3.9		

Results

The composition of the feedstuffs used in this trial is shown in table 1 (oven dry basis). It may be noted that the copper content of the silage, used as primary feed, averaged 7.5 ppm, while that of the grain and hay fed simultaneously was 5.7 and 4.6 ppm, respectively. The difference in iron content of the two silages (193 and 893 ppm) was probably caused by variation in the iron content between different lots of molasses used in silage preparation. Molasses samples in past analyses have shown iron contents of 122, 141, 463, 876, 2722, 2820 and 2864 ppm.

Weight and feed consumption data for the animals on experiment are presented in table 2. It is apparent that the animals receiving supplementary minor elements showed increased gains, increased feed consumption (silage, grain and hay) and equivalent feed efficiency compared to those which received the same ration without supplement. The difference of 0.36 lb. gain between the control and trace element

TABLE 2. ANIMAL DAILY GAINS AND FEED CONSUMPTION

	Control	Supplemented
No. animals	5	5
No. of days	122	122
Initial wt. lb.	394.8	384.6
Final wt. lb.	609.0	642.6
Total gain (per group)	214.2	258.0
Daily gain, lb.	1.8	2.1
Hay consumed, lb.	0.5	0.5
Silage consumed, lb.	19.6	22.5
Grain consumed, lb.	4.6	4.7
Dicalcium phosphate, gm.	16.18	11.8
Steamed bone meal, gm.	4.36	7.70
Salt, gm.	27.74	29.95

groups was significant at the 10%, but not at the 5% probability level.

Considerable variation existed in consumption of minor elements offered half the animals by the free-choice method. Intake data for individual animals are presented in table 3.

Copper and iron contents of liver tissue obtained by biopsy at intervals throughout the trial are listed in table 4, with corresponding blood and plasma copper values. Sample I was obtained on 14 December, 1954; Sample II on 29 March, 1955; Sample III on 23 May, 1955; and Sample IV on 29 November, 1955. During the post trial period (6 months) between Sample III and Sample IV the experimental animals were returned to the station herd for summer pasture grazing. Sample IV demonstrates a return to the marginal liver copper values found in unsupplemented animals of this area.

All animals appeared healthy and made reasonable gains throughout although one animal in the control group was inclined to be nervous

TABLE 3. FREE CHOICE MINERAL CONSUMPTION, 122-DAY TRIAL

Calf no.	Copper	Cobalt	Magnesium	Inorganic sulfate
	mg.	mg.	mg.	mg.
56	1275	94	3140	9840
47	5408	147	14470	45360
53	730	65	7530	24220
45	2438	101	6530	20480
44	725	49	3020	9480
Av./animal/day	17.3	0.7	60	180

TABLE 4. COPPER AND IRON CONTENT OF BLOOD AND LIVER SAMPLES, ppm

Animal no.	Plasma Cu				Blood Cu				Liver Cu[a]				Liver Fe[a]			
	Sample no.				Sample no.				Sample no.				Sample no.			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
							Controls									
43	0.828	0.944	0.892	0.562	0.957	1.020	0.842	0.740	16.2	15.4	20.1	16.4	373	255	194	...
51	0.688	0.880	1.072	0.459	0.778	0.905	1.058	0.459	14.1	15.8	27.4	8.3	...	253	173	...
54	0.536	0.791	0.931	0.421	0.677	0.842	0.943	0.497	12.7	13.6	12.2	8.7	438	280	148	...
55	0.880	0.651	0.854	0.574	0.995	0.817	.....	0.612	39.0	25.3	51.0	15.2	702	381	189	...
58	0.345	0.752	1.019	0.447	0.472	0.842	0.931	0.472	11.9	21.3	15.2	7.2	402	220	187	...
Av.	0.655	0.893	0.953	0.492	0.775	0.895	0.943	0.556	18.8	18.7	25.1	11.2	478	278	178	...
							Supplement[b]									
44	0.600	0.905	0.982	.....	0.778	0.944	0.892	.....	13.0	23.2	30.6	....	547	207	157	...
45	0.867	1.071	0.587	1.058	0.905	1.071	0.676	0.892	15.6	56.3	53.0	17.7	326	295	174	...
47	1.083	0.842	1.083	0.625	0.932	0.968	0.957	0.778	14.2	72.6	78.9	38.6	508	260	172	...
53	0.778	0.842	0.892	0.867	0.918	0.918	0.892	0.803	33.6	35.9	46.3	22.2	401	294	166	...
56	0.447	.....	0.892	0.459	0.651	0.702	.....	0.497	12.5	14.4	11.1	11.2	632	254	211	...
Av.	0.755	0.932	0.887	0.752	0.836	0.920	0.854	0.742	17.8	40.5	43.9	22.4	482	262	176	...

[a] Dry weight.
[b] Supplemented free choice with salt containing: 0.99% $CuSO_4 \cdot 5H_2O$, 0.0207% $CoCO_3$, and 9.86% $MgSO_4 \cdot 7H_2O$.

when strangers were present. Every animal showed a loose condition at least once, but no animal developed a thin, persistent watery type of scours. Periodic fecal checks at the time of the biopsies indicated only low worm egg counts in all but two animals which were described as having a "moderate" number of ova. At termination of the trial, only one animal showed a "few" stomach worm ova. Four were classed as having a "few" coccidia and three had "moderate" numbers of coccidia.

Discussion

Variation in the intake of the minor mineral elements offered on a free-choice basis makes interpretation of the data difficult. Insofar as average figures may be meaningful, however, it will be noted that under the dietary regimen imposed, the intake of cobalt, copper and magnesium was 0.7, 17.3 and 60 mg. daily respectively, or in proportions of about 1:25:86. Generally speaking it might be argued that the presence of the minor mineral elements increased the palatability of the ration as a whole. A corollary, namely the cobalt deficiency restricts dietary intake, has been expressed previously by Stewart (1953).

It is interesting to consider the trace element contents of blood and liver tissue in the light of supplies in the feed, both in this experiment and in others reported in the literature. As far as dietary copper is concerned, under Australian and New Zealand conditions, Beck (1941) and Cunningham (1945) consider a minimum of 7–8 ppm in the diet as adequate to prevent simple copper deficiency. Copper values of 8–9 ppm or higher are required in the presence of 2.5 ppm molybdenum.

Allcroft (1952) found that "swayback," a complicated copper deficiency disease of sheep, was avoided when additional copper was fed. In the region where this phenomenon occurred, the forage was found to contain 7–20 ppm copper and 4.8–2.5 ppm molybdenum. Jamieson and Allcroft (1950) traced a condition known as "copper pine" in calves to liver copper values of 20 ppm. This condition was found to occur in animals grazing pasture forage having a mean of 9.8 ppm copper and 2.9 ppm molybdenum.

In view of such reported findings, the molybdenum values of Lotus hay and silage fed during the first 78 days of the experiment seem rather high (2.6 and 5.8 ppm). It might be postulated that animal 47 overcame the molybdenum handicap by consuming a total of 5,408 mg. copper and increasing its liver copper from 14 to 79 ppm during the trial period. In direct contrast, however, the liver copper values of ani-

mal 56 remained unchanged even though it consumed 1,275 mg. copper during the trial period.

The free choice intake of inorganic sulfates as noted in table 3 may have influenced the liver copper storage. Dick (1953) suggests that inorganic sulfates influence molybdenum excretion allowing the animal to accumulate copper reserves. However, it must be kept in mind that there was a great difference in the amounts of copper consumed as well as in the inorganic sulfates.

The over-all rise in liver copper values in the control group of calves was slight. The copper intake from the forage was not sufficient to cause a statistically significant increase in liver copper. The free-choice supplemented group showed a liver copper increase which was significant at the 5% level.

The whole blood and plasma copper values presented in table 4 show no consistent trend. It is interesting, however, that the highest blood copper at the start of the experiment was from the animal (No. 55) with the highest liver copper while the same relationship held true for the lowest copper animal (No. 58). Lack of correlation between blood and liver copper values was encountered previously by Loosmore and Allcroft (1951).

Although hemoglobin values were not obtained for individual animals in this experiment, it should be noted that hemoglobin and plasma copper values had been previously determined for 82 animals at this station. The average hemoglobin value was 11.1 gm. per 100 ml. of blood with individual extremes of 14.8 and 7.7 deviating from the usual 10.0–12.0. Since a lack of correlation between hemoglobin and plasma copper values existed, a high value for copper may or may not accompany a high hemoglobin value.

As the experiment progressed there was a decline in iron content of the liver in both the control and supplemented groups, which must go unexplained. This decline in view of the silage iron content of 893 ppm for the last 45 days as compared to 193 ppm during the first 78 days of the experiment is significant. The initial high liver iron values may be related to copper deficiency as discussed by Marston *et al.* (1938). Similarly, Elvehjem and Sherman (1932) showed that for rats additional copper in the diet caused a decrease in liver iron.

Sampling IV, made approximately 6 months following termination of the supplementation program, illustrates the inability of animals to retain increased copper stores on low copper diets common to the Oregon Coastal Area.

Summary

Two groups of five female Hereford calves were fed grass silage prepared with sugar beet molasses, grain, limited hay, and offered dicalcium phosphate, steamed bone meal and plain salt on a free choice basis. One group served as controls while the other received copper sulfate, cobalt carbonate, and magnesium sulfate offered free choice, mixed with common salt.

The control group gained 1.76 lb. per day while the group having free access to trace minerals gained 2.11 lb. per day. This difference proved statistically significant at the 10% probability level.

Increased total ration consumption was noted in the animals receiving the trace mineral supplement.

On the diets listed, the animals having free access to magnesium, copper and cobalt salts averaged an intake of 60, 17.3 and 0.6 mg. per day, respectively.

Whole blood and plasma copper values did not consistently reflect the low liver values of either group. Extremes in high and low liver copper at the start of the experiment were, however, accompanied by extremes in blood copper.

There was a slight increase in liver copper content for both groups. The difference in the final copper content between control and supplemented groups was significant at the 5% level.

Liver iron storage decreased while copper storage increased.

The animals did not show an ability to correct their low level copper stores through free choice selection of a copper-containing salt mixture.

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DICALCIUM PHOSPHATE AND SOFT PHOSPHATE WITH COLLOIDAL CLAY AS SOURCES OF PHOSPHORUS FOR BEEF HEIFERS

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IN the processing of the phosphate matrix to produce a high grade rock phosphate, the phosphate washing plants produce a waste product referred to as "soft phosphate with colloidal clay" [2] or waste pond phosphate. This product contains a relatively high percentage of phosphorus and can be supplied at a price favorable to its use for livestock feeding. Recent research work has shown that colloidal clay is not a satisfactory source of phosphorus for the chick (Gerry *et al.*, 1947; Miller and Joukovsky, 1953; Gillis *et al.*, 1954). Grau and Zweigert (1953) concluded that the fluorine content of their colloidal clay did not appear to account for its effect upon the growth rate of chicks.

Chapman *et al.* (1955) reported that colloidal clay fed to pigs produced less rapid rate of gain than steamed bone meal or dicalcium phosphate. However, Gobble and Miller (1953) and Plumlee *et al.* (1955) observed no significant difference in rate of gain or plasma inorganic phosphorus between groups of pigs fed colloidal clay and those fed dicalcium phosphate.

Ammerman *et al.* (1954) using a balance technique, observed no significant difference in phosphorus retention between steers fed various inorganic phosphates as sources of phosphorus. Supplements tested were dicalcium phosphate, bone meal, deflourinated rock phosphate, imported rock phosphate, and colloidal clay.

The purpose of the present study was to determine the comparative value for cattle of phosphorus from colloidal clay and dicalcium phosphate when each was fed at a level below that required for optimal growth.

Experimental Procedure

The experiment was divided into three consecutive periods, period 1 being a depletion period for all animals. During period 1 the experi-

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[2] For brevity, the term colloidal clay is used in this paper.

mental animals, 12 Angus × grade Hereford and 12 grade Hereford heifers, were self-fed a low phosphorus basal ration of the composition shown in table 1. At the end of this 68-day depletion period, the animals were allotted into three groups, each group having four crossbred and four Hereford animals.

During period 2, the heifers of group 1 were continued on the basal diet (ration 1); group 2 received the basal plus 0.05% supplemental phosphorus supplied by colloidal clay (ration 2) and group 3 received the basal plus 0.05% supplemental phosphorus supplied by dicalcium phosphate (ration 3). All groups were group-fed from self-feeders

TABLE 1. PERCENTAGE COMPOSITION OF EXPERIMENTAL RATIONS

Ingredients	Ration 1 (Basal)	Ration 2 (Colloidal clay)	Ration 3 (Dicalcium phosphate)
Cottonseed hulls	36.30	36.30	36.30
Dried beet pulp	27.20	27.20	27.20
Dehydrated alfalfa meal	9.10	9.10	9.10
Cerelose	18.00	18.00	18.00
Corn gluten meal	9.10	9.10	9.10
Urea (Two-Sixty-Two)	0.10	0.10	0.10
A and D supplement [a]	0.20	0.20	0.20
Dicalcium phosphate			0.27
Colloidal clay [b]		0.67	
Calcium carbonate [c]		0.09	0.14
P from supplement	0.00	0.05	0.05
P from basal	0.09	0.09	0.09

[a] Contributed vitamin A, 2724 I.U. and vitamin D, 340 I.U. per lb. of total ration.
[b] Contained 0.97% fluorine.
[c] To keep calcium: phosphorus ratio about 4:1.

during the 98-day period. Weights were taken at 14-day intervals. A 12-hour shrink period, during which time the animals were without feed or water, preceded each weighing. Feed consumption was determined monthly.

The four crossbred heifers in each group were slaughtered at the end of period 2 and the cannon and mandible bones were removed for determination of ash. A section one inch long was taken from the middle of the cannon bone for measurement of average thickness. Three measurements were made at each end of the section and the values averaged

During period 3, the four Hereford animals remaining in each group were continued on feed for an additional 80 days with the following change: Group 1 received a supplement of 0.05% phosphorus as dicalcium phosphate (ration 3). Groups 2 and 3 were continued on

TABLE 2. AVERAGE GAIN IN WEIGHT AND PLASMA INORGANIC PHOSPHORUS DURING PERIOD 2 (98 DAYS)

Item	Group 1 (Basal)	Group 2 (Colloidal clay)	Group 3 (Dicalcium phosphate)
Initial wt., lb.	464	467	469
Final wt., lb.	503	524	614
Gain, lb.	39	57	145
Initial plasma P, mg. %	2.9	2.7	2.5
Final plasma P, mg. %	2.0	2.8	3.7
Gain, mg. %	—0.9	0.1	1.2

rations 2 and 3, respectively. Management and weighing were the same as in period 2.

Blood samples for plasma phosphorus determinations were obtained by jugular puncture at 14-day intervals. Phosphorus determinations in the plasma and feeds were made colorimetrically by modification of the method of Fiske and Subbarow (1925). The data were analyzed statistically by analysis of variance (Snedecor, 1946) and multiple range test (Duncan, 1955).

Results

The results obtained during periods 2 and 3 are shown in tables 2 and 3, respectively.

Weight Gain

During period 2, the heifers receiving dicalcium phosphate (group 3) gained 88 lb. more than those receiving an equal amount of phosphorus from colloidal clay (group 2) and 106 lb. more than those receiving the basal ration (group 1). The differences were significant at the 1% level

TABLE 3. AVERAGE GAIN IN WEIGHT AND PLASMA INORGANIC PHOSPHORUS DURING PERIOD 3 (80 DAYS)

Item	Group 1 (Dicalcium phosphate	Group 2 (Colloidal clay)	Group 3 (Dicalcium phosphate)
Initial wt., lb.	482	491	586
Final wt., lb.	552	509	662
Gain, lb.	70	18	76
Initial plasma P, mg. %	2.0	2.4	3.6
Final plasma P, mg. %	2.7	2.4	3.4
Gain, mg. %	0.7	0.0	—0.2

of probability. The group which received colloidal clay gained only 18 lb. more than the basal group. If the growth response to dicalcium phosphate (106 lb.) is given a value of 100, the growth response to colloidal clay (18 lb.) in this experiment is only 17.

During period 3, the heifers of group 1 which were changed from the basal ration to one supplemented with dicalcium phosphate gained 0.87 lb. daily, a 118% increase over their performance during the preceding 98-days when they received only the basal ration. There was very little change in the performance of the heifers continued on dicalcium phosphate, except for a decreased rate of gain, while those continued on colloidal clay decreased markedly in rate of gain. These animals had trouble walking and appeared to be in pain. In fact, their joints creaked.

Feed Consumption

The average daily feed consumption during period 2 was 9.5, 12.0, and 14.8 lb. for groups 1, 2, and 3, respectively. Appetites of the heifers receiving the basal ration decreased throughout the experiment, and were depressed in the heifers consuming colloidal clay especially toward the end of the period.

During period 3, group 1 which had previously received the basal diet increased their daily feed consumption from 9.5 to 11.2 lb. Group 2 receiving colloidal clay, however, decreased their daily feed consumption from 12.0 to 8.9 lb., while group 3, continued on the dicalcium phosphate supplement, slightly increased their daily consumption from 14.8 to 14.9 lb.

Plasma Inorganic Phosphorus

At the end of period 1 (depletion), the heifers allotted to groups 1, 2, and 3 had average plasma inorganic phosphorus value of 2.9, 2.7, and 2.5 mg. %, respectively. At the end of period 2, group 1 had an average value of 2.0 mg. %; groups 2 and 3 had values of 2.8 and 3.7, respectively. The value for group 3 was significantly higher than that for either group 1 or group 2. The difference between the values for group 1 and 2 was not statistically significant at the 5% level. If the difference in plasma phosphorus between group 1 and 3 is ascribed to dicalcium phosphate and assigned a value of 100, the relative value of colloidal clay is 45.

At the end of period 3, heifers of group 1 showed a gain in plasma

phosphorus of 0.8 mg % as the result of supplementation of their ration with dicalcium phosphate. There was no significant change in the other two groups.

Bone Data

The average percentage ash of the cannon bones on a dry, fat-free basis was 55.5, 57.1, and 59.2 for the heifers of groups 1, 2, and 3, respectively. Only the difference between group 1 (basal) and group 3 (dicalcium phosphate) was statistically significant ($P<0.01$).

The percentage ash of the mandible on a dry, fat-free basis was 61.4, 62.3, and 64.9 for groups 1, 2, and 3, respectively. In this comparison the value for group 3 was significantly greater than that for either group 1 or 2 ($P<0.01$).

The thickness of the diaphysial wall of the cannon bone (average of six measurements) was 2.8, 3.0, and 2.9 mm. for the heifers in groups 1, 2, and 3, respectively. This difference between group 2 and groups 1 or 3 was statistically significant ($P<0.01$).

Discussion

For the purpose of determining the relative value of colloidal clay as a phosphorus supplement, a comparison was made with dicalcium phosphate and the growth response attained with the latter supplement assigned a value of 100. On this basis the growth response obtained with colloidal clay was only 17. When plasma inorganic phosphorus was used as the criteria, the value of colloidal clay was 45. This is in general agreement with the results reported in studies with chicks.

In the present experiment the cannon bone and mandible of heifers fed colloidal clay contained significantly less ash than those fed dicalcium phosphate; however, the cannon bone wall of the colloidal clay-fed heifers was thicker. Heifers fed dicalcium phosphate gained an average of 1.5 lb. daily and appeared normal. Heifers fed the basal ration had rough hair coats, slight enlargement of the joints, and one heifer was lame. The heifers fed colloidal clay were less thrifty than the other heifers. Their hair coats were rough and they were emaciated. All had enlarged joints and two of them walked with difficulty. These heifers and those fed the basal ration chewed on wood, wire, and other foreign material, and were also coprophagous.

At the end of period 3, there were noticeable changes in the general appearance of the heifers. Those fed dicalcium phosphate after having

ceived the basal ration in periods 1 and 2 showed only occasional signs of pica and coprophagy. However, one heifer was "creepy". Two of the heifers continued on the colloidal-clay ration were stiff; their hoofs were elongated, and they walked with difficulty. Pica and coprophagy were evident also. One heifer which had been fed dicalcium phosphate only in period 3 and two heifers from the colloidal-clay group were slaughtered because of their extremely poor physical condition. The latter two heifers showed exostosis on the cannon bone and wearing away of the teeth. There were no signs of tooth mottling. The remaining nine heifers were returned to the college experimental range. Within 2 weeks, however, it was necessary to slaughter one of the two heifers fed colloidal-clay because she became unable to walk. The remaining one was slaughtered after 57 days on grass; during this period she lost 123 lb. All the other heifers were slaughtered after approximately 3 months on grass.

The colloidal-clay ration contained 65 ppm. of fluorine contributed by the supplement (0.97% flourine). Mitchell and Edman (1952) stated that the level of flourine in rock phosphate which is on the border line of toxicity for cattle is about 100 ppm. of the total dry ration.

Summary

Three groups of eight beef heifers each were used to determine the relative value of soft phosphate with colloidal clay as an inorganic phosphorus supplement for growing beef heifers. One group was fed a low-phosphorus basal ration, 0.09% P, and the other two groups were fed the basal ration supplemented with 0.05% phosphorus as colloidal clay and as dicalcium phosphate. Principal criteria of response were weight gains, plasma inorganic phosphorus, and ash content of cannon bone and mandible. Differences in responses between the colloidal clay and dicalcium phosphate groups at the end of a 98-day period were statistically significant and favored the latter. Heifers fed colloidal clay exhibited pica, coprophagy, and walked with difficulty. They failed to recover when turned out to pasture. Heifers fed dicalcium phosphate were normal.

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SERUM ALKALINE PHOSPHATASE AND GAIN IN BRAHMAN CATTLE [1]

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THE desirability of having an efficient index which will predict future gain in growing-fattening meat animals is obvious. Attempts to predict future gains of young animals in the feed lot on the basis of conformational or "type" characters have not been satisfactory. The correlation between feeder grade and subsequent gains in beef cattle was only 0.09 according to Hawkins and Burk (1938). Similar findings with lambs and steers have been reported by Patterson *et al.* (1949) and Knapp and Clark (1951).

The control of rate of growth in laboratory animals by growth hormone from the anterior pituitary gland demonstrated by Li and Evans (1947) suggests that physiological and biochemical characteristics might indicate differences in gaining ability. The possibility that serum alkaline phosphatase activity might serve as a biochemical index of subsequent gain was based on the observation of Li *et al.* (1946, 1947) that pituitary growth hormone treatment increased the phosphatase level and that hypophysectomy was followed by a decline in phosphatase. Kunkel *et al.* (1953) reported distinct breed differences in phosphatase activity but a small negative correlation between phosphatase level and subsequent gain in Hereford and Angus bulls and steers. A highly significant positive correlation between phosphatase level and subsequent gain in a group of Brahman bulls was later reported by Kunkel *et al.* (1954). The objective of the present report is to present the results of more recent and extensive investigations of the relationship between serum phosphatase and subsequent gain in immature Brahman cattle.

Experimental Methods

The animals used in the investigation were part of the cattle on record-of-performance test at Substation 23 of the Texas Agricultural Experiment Station in each of three years. These performance tests

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required that all cattle be maintained under uniform conditions and receive the same diet self-fed. There were a total of 53 bulls and 68 heifers included in the study. The initial age of the cattle ranged from approximately 8 to 11 months. The length of the feeding period was 140 days in two of the years and 154 days in the third year. The initial weights were recorded following a preliminary adjustment period of 14 days.

Within 15 days of the beginning of the feeding period blood samples for serum alkaline phosphatase determination were collected by venipuncture. The samples were allowed to clot and the serum was removed

TABLE 1. THE AGE, WEIGHT, SERUM PHOSPHATASE AND GAIN OF THE CATTLE IN THE THREE YEARS

Group	Number of animals	Average initial age	Average initial weight	Average initial phosphatase	Average final weight	Average gain
		days	lb.	units	lb.	lb.
1953						
Bulls	24	273(23)[a]	516(64)[a]	6.97(2.06)[a]	760(77)[a]	242(46.8)[a]
Heifers	15	281(26)	441(56)	8.16(2.77)	626(74)	185(34.5)
Combined	39	276(24)	487(70)	7.43(2.43)	708(99)	220(50.5)
1954						
Bulls	15	260(26)	505(49)	6.38(1.63)	769(65)	264(34.5)
Heifers	38	262(34)	454(56)	6.01(1.91)	649(64)	194(26.6)
Combined	53	261(31)	469(59)	6.12(1.82)	683(83)	215(42.4)
1955						
Bulls	14	260(23)	440(57)	4.43(1.12)	728(57)	238(20.0)
Heifers	15	282(22)	425(53)	4.31(1.29)	640(89)	215(47.5)
Combined	29	271(25)	432(55)	4.39(1.19)	682(87)	250(51.8)

[a] Average; ( ) standard deviation.

by centrifugation. The phosphatase determinations were made immediately, or the serum was stored at —10° C. until the determinations could be carried out. In all cases the analyses were completed within ten days of the date of collection of the blood samples. Serum alkaline phosphatase activity was determined by the method of Bessey *et al.* (1946) in which 0.1 ml. of serum is used. This method utilizes paranitrophenyl phosphate as the substrate and the activity is expressed as "millimole units" per liter of serum. Two blood samples were taken from each animal and duplicate determinations were made on each of these samples. This resulted in quadruplicate determinations from each animal.

The relationships among the serum phosphatase activity, initial age, initial weight and gain, expressed as correlation coefficients, were

determined on both a within-year and a within-year-and-sex basis. The usual methods as outlined by Snedecor (1950) were utilized for these calculations.

Results and Discussion

The similarity of the cattle at the beginning of the feeding period in each of the three years is indicated by table 1. It is evident also from this summary that performance was fairly uniform from year to year.

TABLE 2. CORRELATIONS INVOLVING INITIAL AGE, INITIAL WEIGHT, INITIAL PHOSPHATASE AND GAIN

Group	Age and gain	Weight and gain	Phosphatase and gain	Age, weight and gain	Phosphatase, age, weight and gain
1953					
Bulls	.19	—.05	.63**	.21	.70**
Heifers	.16	.29	—.02	.30	.33
Combined[a]	.17	.04	.30	.17	.34
1954					
Bulls	.09	.33	—.35	.33	.62
Heifers	—.41**	.46**	.45**	.52**	.79**
Combined	—.28	.12	.21	.29*	.33*
1955					
Bulls	—.03	—.18	.07	.24	.25
Heifers	.19	.18	.43	.23	.66
Combined	.11	.32	.31	.33	.45

[a] When combined, gains adjusted for difference in sex.
* Significant at 0.05 level.
** Significant at 0.01 level.

The average serum phosphatase activity declined from 7.43 units in 1953 to 4.39 units in 1955. Although animal variability or environmental factors may be responsible, this decline in phosphatase activity might reasonably be attributed to unknown differences in procedure as the determinations were made by different technicians in the different years.

Table 1 reveals that the phosphatase activity was greater in the heifers in the first year, but greater in the bulls in the last two years. These differences between the sexes were tested for significance on a within-year basis by analyses of variance and also by multiple covariance analyses in which age and weight were included as independent variables. The sex difference was significant only in 1954 after adjustment had been made for age and weight differences. The only comparable information provided by the literature are the data of Kunkel *et al.*

(1953) in which no sex effect was found. On the basis of this report and the present data, a real sex influence on phosphatase activity in Brahman cattle in this age range remains doubtful.

The primary objective of this investigation was to determine the usefulness of serum phosphatase activity in predicting subsequent gain. The data essential to this objective are presented in table 2. In the first three columns are shown the gross correlations involving each of the variables: age, weight, phosphatase and subsequent gain in the feed lot. Although the limitations of age and weight as indexes of future performance are recognized, it was deemed of interest to include them here for comparison with phosphatase, especially, in view of the decline in phosphatase activity with age (Kunkel *et al.*, 1953). The correlations involving gain and each of the three other variables were variable and only four proved to be significant statistically. All four of these, two involving phosphatase and gain, one involving age and gain and one involving weight and gain, were based on data for only one sex.

Perhaps attention should be directed to the correlations secured from the combined data for the two sexes. Before combining the sex groups in each year, the difference in gain between the sexes was tested for significance. As these differences were significant, the gains were corrected for sex before calculating the correlations shown in table 2. None of the simple correlations based upon the combined data were significant. However, the correlations involving phosphatase and gain were less variable than correlations involving either age or weight and gain. Correlations for phosphatase ranged from 0.21 to 0.31 while the range of age correlations was —0.28 to 0.17.

The relationship between phosphatase and gain was further investigated by utilization of the gain ratio technique described by Warwick and Cartwright (1955). In the present study both gain and phosphatase activity were converted to ratios on a within-sex-and-year basis (phosphatase ratio=observed phosphatase/mean for sex and year). A single correlation coefficient between phosphatase ratio and gain ratio for all animals was calculated. This coefficient was 0.20, significant at the 0.05 level of probability.

While this investigation was in progress it was possible to secure some additional data from cattle on a privately owned ranch in the area. There were 15 heifers and 27 bulls of approximately the same initial age as the cattle at Substation 23. Initial phosphatase determinations on these cattle were adjusted to a uniform age within each sex group. Weights were taken 130 days later and also adjusted to a uniform

age. The correlation between phosphatase activity and later weight was determined on a within-sex basis. This correlation was 0.42 in both sex groups, but was significant only with the bulls as this was the larger group. It must be noted that the weight used here consisted of gains made before and after the phosphatase determination. It is impossible to determine which portion of the gain contributed the major part to the observed correlation between phosphatase activity and gain.

Two multiple correlations which are shown in the last two columns of table 2 seemed worthy of investigation. The first of these relationships was that involving gain, age and weight and the second included phosphatase as a fourth variable. In these correlations gain was considered the dependent variable and age, weight and phosphatase were considered independent variables. Although several other comparisons might be made, it was of primary interest to the objective of this investigation to compare these multiple correlations with the phosphatase-gain correlation. Considering the combined data only, it is interesting to note that in 1953 phosphatase alone would have been more efficient in predicting gain than age and weight combined. In 1955 phosphatase was slightly less efficient than age and weight together, but in the 1954 analysis age and weight combined gave greater efficiency of prediction than did phosphatase alone.

The maximum efficiency possible in predicting gain in these data would be secured when age, weight and phosphatase were utilized as independent variables. A comparison of the two multiple correlations presented in table 2 shows that in 1953 and 1954 appreciable increases in efficiency of prediction of gain resulted from the inclusion of serum phosphatase among the variables. An increase was observed in 1955, but it was not as marked as in the other two years. An appreciable portion, 36 to 90%, of the variation in gain is not accounted for by the predictions used in this study. These data suggest the need for a sufficient number of added variables to make the coefficient of determination or fraction of the variation in gain accounted for by the regression on the independent variables (R^2) approach unity or at least attain a practically useful magnitude. It would be possible under such circumstances to evaluate more properly the relationship of serum phosphatase and gain in cattle.

Summary and Conclusions

The relationship between gain and certain other selected variables was investigated with three groups of Brahman cattle serving as experi-

mental animals. The relationship of serum alkaline phosphatase activity and subsequent gain was quite variable, gross correlations between the two variables ranging from 0.63 to —0.35. Most of the correlations between phosphatase and gain were positive, and only positive correlations were significant statistically.

By means of multiple correlation, the relationship of initial age, initial weight and phosphatase activity to subsequent gain was investigated. The use of the three independent variables yielded an improved prediction of gain as compared to that secured by the use of only one or two independent variables, but in some instances, this improvement was rather slight. It appears that these data are too limited to merit a final conclusion as to the practicability of the routine determination of phosphatase activity for inclusion of this variable in an equation for the prediction of gain in Brahman cattle.

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THE UTILIZATION OF UREA NITROGEN BY YOUNG DAIRY CALVES [1]

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As reviewed by Reid (1953), various workers have demonstrated that nitrogen supplied in the form of urea can be incorporated into protein by animals with well developed rumina. However, limited studies have been made with calves. Loosli and McCay (1942) found that calves 2 months old were unable to grow on a ration containing only 4.4% protein. Calves fed a similar ration to which urea was added in amounts to give a protein equivalent level of 16.2% increased in body weight to 75–90% of normal (Morrison, 1936) at 4 months of age.

The present study was conducted to determine the usefulness of urea as a source of nitrogen for young dairy calves from 2 to 86 days old when raised on a limited milk-hay-starter-system, and to study the influence of cud inoculations on the utilization of urea.

Experimental Procedure

Thirty-six, 2-day-old male and female calves were randomly selected and divided into three equal groups based on body weight. Each group composed of six Jersey and six Holstein calves was raised to 86 days of age on a limited milk-hay-starter system. The three experimental starters (table 1) were pelleted and fed *ad libitum* to the calves from 2 days of age, an upper daily limit of 6 lb. being fed to the Jerseys and 8 lb. to the Holsteins. A medium quality timothy hay was fed *ad libitum* to all calves. Milk was fed at the daily rate of 8% of body weight for the first 21 days. From 22 to 49 days of age the level of milk was reduced to 6, 5, 3 and 2% of body weight at weekely intervals all calves being completely off milk at 49 days of age.

All calves were weighed at 2 days of age and at weekly intervals thereafter to 86 days. Skeletal measurements were made at 2 days and 86 days of age. The calves were observed daily, and records were kept

[1] The authors express their appreciation to Lederle Laboratories, Pearl River, N. Y. for supplying the Aureomycin supplement and to Allied Dye and Chemical Corp., New York, N. Y. for supplying the urea used in this study. The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

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of consumption of milk, starter, and hay as well as the incidence of scours.

Digestion and nitrogen balance studies were conducted with six male calves from each experimental group at the ages of 5, 8 and 11 weeks. Blood samples were taken from the same calves at 2 days and at 2, 4, 6, 8, 10 and 12 weeks of age. Blood plasma protein, non-protein nitrogen and urea determinations were made immediately according to accepted procedures (Hawk *et al.* 1947; Folin and Wu, 1919; Van Slyke and Cullen, 1914).

TABLE 1. COMPOSITION OF CALF STARTERS

Starter number	1	2	3
Ingredients (lb.)			
Ground yellow corn	260	260	
Crimped oats	100	100	100
Corn starch	220	190	170
Molasses	100	100	100
Trace mineralized salt	10	10	10
Bone meal	10	10	10
Timothy hay	300	300	300
Urea		30	
Linseed oil meal			310
Aurofac D [a]	+	+	+
Vitamin A and D supplement [b]	+	+	+
Composition (%)			
Dry matter	91.9	91.0	91.6
Crude protein	6.7	15.1	15.2
Ether extract	2.1	3.0	2.4
Crude fiber	8.2	10.4	13.8
N.F.E.	70.4	57.5	53.6
Ash	4.5	5.0	6.6
Nitrogen in form of urea		54.2	

[a] 15 mg. of chlortetracycline per lb. of feed.
[b] 500 gm. per 1000 lb. starter.

Six calves (three Jerseys and three Holsteins) from each experimental group were given fresh cud inoculations once each week for the first 6 weeks of life.

Results and Discussion

In figure 1 the relative growth rates of the three experimental groups are shown in increments of two weeks. All of the calves increased in body weight at comparable rates for the first 6 weeks, which can probably be attributed to the whole milk feeding. At 6 weeks the calves

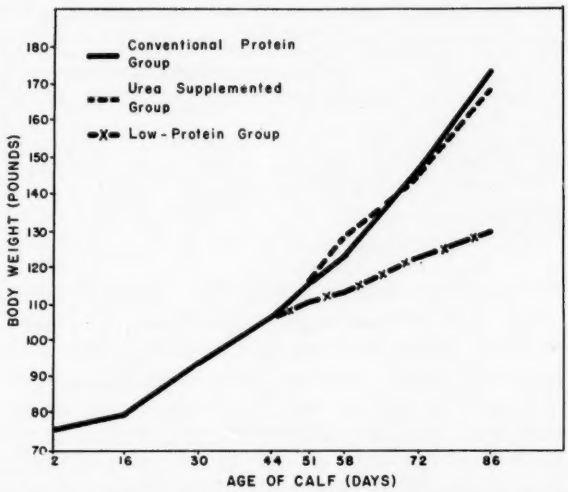

Figure 1. Growth rate of the three experimental groups of calves from 2 to 86 days of age.

were receiving milk at the rate of 2% of body weight and were completely off milk at 7 weeks. The low-protein group gained approximately 24 lb. from the 6th to the 12th [illegible] as compared with 64 and 67 lb., respectively, for the urea-supplemented and conventional-protein groups. Evidently the urea-supplemented group of calves was able to utilize sufficient urea to make above normal growth (Ragsdale, 1934) as early as 6 weeks of age.

The daily gain, skeletal growth, and incidence of scours of the calves are shown in table 2. When subjected to analysis of variance (Snede-

TABLE 2. RATE OF GAIN, SKELETAL GROWTH AND INCIDENCE OF SCOURS OF THE CALVES TO 86 DAYS OF AGE

Group	Av. initia wt.	Av. daily gain	Av. increase in		Incidence of scours
			Ht. at withers	Heart girth	
	lb.	lb.	in.	in.	days/calf
1 (low protein)	75.4	0.65	3.73	5.81	2.8
2 (urea supplemented)	75.7	1.10	4.90	7.92	0.9
3 (conventional protein)	76.1	1.16	5.40	9.02	1.2
L.S.D., 1% level		0.26	1.02	1.62	
L.S.D., 5% level		0.19	0.76	1.20	1.4

TABLE 3. FEED CONSUMPTION AND UTILIZATION DATA
(Values in lb.)

Group	Average total consumption per calf			Feed per lb. gain
	Milk	Starter	Hay	
1 (low protein)	212.7	166.5	19.3	3.89
2 (urea supplemented)	218.7	234.2	15.6	2.98
3 (conventional protein)	226.0	228.2	22.1	2.86
L.S.D., 1% level		49.4		0.42
L.S.D., 5% level		36.7		0.31

cor, 1946) these data show no statistically significant differences in average daily gains, increase in height at withers and chest circumference between groups receiving the conventional protein and the urea-supplemented rations. However, both groups as compared to the low protein group, gained at a significantly faster rate and increased significantly more in skeletal growth ($P<.01$). There were only 2.8, 0.9, and 1.2 days of scouring per calf for the low-protein, urea, and conventional groups, respectively; however the incidence of scours was significantly higher ($P<.05$) for the low-protein group than for the other experimental groups.

Feed consumption and utilization by the calves is shown in table 3. Consumption of the low-protein starter was significantly less ($P<.01$) that that of the other two starters. Hay consumption was relatively low in all groups as might be expected since each starter contained 30% timothy hay. There was no significant difference between the urea sup-

TABLE 4. AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY AND DAILY NITROGEN RETENTION

	Ration			L.S.D.	
	1	2	3	1%	5%
Av. daily dry matter intake (gm.)	1148	1432	1481		
Nitrogen intake (gm.)	15.2	39.0	40.6		
Percent protein of total feed intake	8.6	17.4	17.4		
Nitrogen retained (gm.)	5.0	16.3	20.2	5.42	4.06
Percent nitrogen retained of intake	32.9	41.8	48.6		
Apparent digestibility (%)					
Dry matter	72.1	75.2	74.3		
Crude protein	56.9	79.0	77.2	5.01	3.76
Ether extract	84.0	83.0	80.7		
Crude fiber	8.1	27.8	38.1	12.86	9.65
N-free extract	80.8	82.8	81.7		

plemented and conventional protein groups in efficiency of feed utilization. Feed efficiency was significantly higher ($P<.01$) for both groups than the low protein group.

The average coefficients of apparent digestibility and daily nitrogen

TABLE 5. APPARENT DIGESTIBILITY COEFFICIENTS AND NITROGEN RETENTION VALUES OBTAINED WITH CALVES AT 5, 8 AND 11 WEEKS OF AGE

Age	Group 1	Group 2	Group 3	Average
wk.				
		Dry matter		
5	73.9	79.0	81.0	78.0
8	70.8	72.7	70.7	71.4
11	71.6	74.0	71.4	72.3
		Crude protein		
5	64.1	81.6	82.2	76.0
8	50.6	76.2	74.1	67.0
11	55.9	79.2	75.3	70.1
		Crude fiber		
5	5.1	26.8	45.8	25.9
8	7.8	28.2	34.8	23.6
11	11.6	28.5	33.8	24.6
		Daily nitrogen intake		
5	15.6	21.3	26.4	21.1
8	14.7	37.6	39.0	30.4
11	15.4	58.1	56.3	43.3
		Nitrogen retention		
5	5.0	9.2	12.7	9.0
8	4.5	13.3	18.8	12.2
11	5.4	26.4	29.1	20.3
		Percent retained of intake		
5	32.0	43.2	48.1	41.1
8	30.6	35.4	48.2	38.1
11	35.1	45.4	51.7	44.1

retention values are presented in table 4. The average coefficients of digestibility of protein and crude fiber were significantly lower ($P<.01$) for the low-protein group than for the other experimental groups. Crude fiber digestibility was significantly lower ($P<.05$) for the urea-supplemented group, than for the conventional-protein group. The results indicate that rumen microbial activity of the low-protein group was mark-

TABLE 6. EFFECT OF CUD INOCULATIONS ON GROWTH, FEED CONSUMPTION, APPARENT DIGESTIBILITY AND NITROGEN RETENTION [a]

Group	Av. daily gain	Feed consumption		Dig. coefficients			
		Starter	Hay	Dry matter	Crude protein	Crude fiber	Nitrogen rentention
	lb.	lb.	lb.				gm./day
Inoculated	0.95	206.6	19.7	75.1	71.9	26.2	14.2
Uninoculated	0.99	212.6	18.4	72.7	70.2	23.2	13.5

[a] No significant difference between groups.

edly reduced because of a shortage of available nitrogen. Differences in nitrogen retention between the urea and conventional-protein groups were not significant. Both groups retained significantly more nitrogen ($P<.01$) than the low protein group.

In table 5 digestibility and nitrogen retention values are given for the three groups of calves at different ages. Average protein digestibility was significantly higher at 5 weeks than at 8 or 11 weeks of age. This difference can probably be attributed to the proportion of milk and percentage of protein fed during the earlier period. There were no significant differences between periods in crude fiber digestibility. The average nitrogen rentention of all calves was significantly ($P<.01$) greater at 11 weeks of age than at either 5 or 8 weeks of age, although no significant difference existed in the percent nitrogen retained of the total intake.

As shown in table 6, cud inoculations had no beneficial effect on

TABLE 7. LEVELS OF PLASMA PROTEIN, NON-PROTEIN NITROGEN AND BLOOD UREA

Week on expt.	Plasma protein (gm./100 ml.)			N.P.N. (mg./100 ml.)			Urea (mg./ml.)		
	Group			Group			Group		
	1	2	3	1	2**	3**	1	2**	3**
0	5.90	5.74	6.44	30.5	27.7	27.5	10.7	10.4	10.8
2	5.93	6.22	5.24	24.3	25.8	25.2	7.9	11.4	12.0
4	5.14	5.46	5.81	15.7	25.8	22.8	2.9	10.2	9.4
6	5.38	5.71	5.73	16.8	22.5	24.2	4.2	11.3	7.6
8	5.37	5.54	5.66	13.5	25.0	22.5	1.5	10.3	7.9
10	5.34	5.25	5.60	14.0	27.0	24.3	2.8	9.7	8.9
12	5.56	5.51	5.71	13.5	22.7	23.2	1.6	8.4	8.6
Av.	5.52	5.63	5.74	18.3	25.2	24.2	4.5	10.2	9.3

** Plasma levels significantly higher ($P<0.01$) than Group 1.

growth, feed consumption, apparent digestibility or nitrogen retention of calves fed the three experimental starters.

The average weekely blood levels of plasma protein, non-protein nitrogen, and urea are given in table 7. There were no significant differences between groups in plasma protein levels. The low-protein group was significantly lower ($P<.01$) in plasma, non-protein nitrogen and blood urea, than either of the other two groups.

The results of this experiment indicate that calves can utilize appreciable quantities of urea to meet nitrogen requirements for growth as early as 6 weeks of age. The urea-supplemented ration was utilized about as efficiently, based upon pounds of feed required per pound of gain, as the conventional-protein ration. Similar results were noted as to the apparent digestibility coefficients of nutrients.

It should be mentioned that it was probably not necessary for the calves fed the starter containing urea to make full utilization of the nitrogen since recent data from this station (Brown *et al.*, 1955) show that calves do not require the amount of nitrogen supplied by this ration. However, since the calves fed the low-protein ration did not make satisfactory growth, it must have been necessary for some of the urea nitrogen to be used for growth. Only future studies at lower levels of nitrogen can determine the extent of urea nitrogen utilization by the young dairy calf.

When this study was initiated, it was thought that if cud inoculation had any measurable beneficial effects on the young calf, these should be expressed with rations containing high amounts of urea nitrogen. Uninoculated calves fed the urea ration gained in weight at a rate of 1.12 lb. daily, whereas the inoculated calves gained 1.09 lb. per day. The coefficients of digestibility of dry matter, protein and crude fiber, were 73.9, 77.8 and 23.8, respectively, for the uninoculated calves fed urea and 76.6, 80.3, and 31.8, respectively, for the inoculated calves. The nitrogen retention values were 26.7 gm. per day for the uninoculated calves and 22.2 gm. per day for the inoculated calves. Since none of these differences in growth, digestibility, or nitrogen retention between treatments were statistically significant, these data fail to show any beneficial effect from cud inoculations.

Summary

Thirty-six, 2-day-old male and female calves (18 Jerseys and 18 Holsteins) were raised to 86 days of age on a limited milk-hay-starter

system to study the value of urea as a source of nitrogen for young dairy calves. Three experimental starters were used: Starter 1 (low protein) 6.7% protein; starter 2 (urea supplement) 15.1% protein equivalent; and starter 3 (conventional-protein supplement) 15.2% protein. Urea supplied 54.2% of the nitrogen in starter 2.

All groups of calves grew at comparable rates for the first 6 weeks during which time whole milk was being fed. When whole milk feeding was discontinued, the urea-supplemented and conventional-protein groups grew at a significantly faster rate than the low-protein group. These two groups consumed significantly more feed and had significantly higher feed efficiency values than the low-protein group. Differences between the conventional protein group and the urea-supplemented group in average daily gain, starter consumption or pounds of feed required per pound of gain, were not significant.

Calves on the low-protein ration digested a significantly smaller percentage of protein and crude fiber and retained less nitrogen than either of the other two groups. Calves on the urea ration digested a lower percentage of crude fiber than those on the conventional protein ration. The results show that a portion of the nitrogen requirements of the young calf can be supplied in the form of urea.

Cud inoculation of calves had no value as measured by growth, feed consumption, apparent digestibility or nitrogen retention.

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THE UTILIZATION OF DICYANDIAMIDE AND UREA BY LACTATING DAIRY COWS *[1]

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With the exception of urea, very little work has been done on the utilization of non-protein nitrogen (NPN) compounds by lactating dairy cows. One of the NPN compounds which has been suggested for use as a protein extender in rations for ruminants is dicyandiamide, which contains approximately 66% nitrogen.

Magruder and Knodt (1954) found that Holstein heifers fed a 16.6% protein-equivalent ration using dicyandiamide to replace 46% of the total protein nitrogen in the grain ration, increased in body weight at about the same rate as heifers fed soybean oil meal as the protein supplement. In a double change-over latin square trial of 15 weeks duration, Lassiter *et al.* (1955) found no significant differences in milk production or body weight changes between cows fed a 13% protein-equivalent concentrate ration with dicyandiamide or urea replacing one third of the total nitrogen when compared to a ration using soybean oil meal as the protein supplement. Davis *et al.* (1956) compared dicyandiamide, urea and soybean oil meal as nitrogen extenders with a ration of below normal protein content in two 56-day continuous trials with lactating cows. Results showed no significant differences between the four rations in body weight changes or milk production. However, lower milk and blood urea nitrogen values were obtained on the cows fed the dicyandiamide and low protein rations.

Belasco (1954) showed that dicyandiamide gave a slower release of ammonia, and poorer cellulose digestion and bacterial growth than urea in the artificial rumen.

The object of this experiment was to determine if dicyandiamide could be utilized as well as urea and soybean oil meal by lactating dairy cows over a long period of time when the protein intake of the cows was equal to or below accepted protein standards.

* The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

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Experimental

Twelve Holstein and 12 Jersey cows were divided at 30 days after calving into three comparable groups of eight cows each and retained on the same ration (table 1) until they went dry or had completed a 305-day lactation. All cows received a medium quality timothy hay as the only roughage. Each cow received up to 2 lb. of hay daily per 100 lb. body weight. However, some cows would not consume this amount of hay. Group A (control) received soybean oil meal; Group B, urea; and

TABLE 1. INGREDIENTS USED IN CONCENTRATE MIXTURES

Ingredient	Rations			
	A	B	C	
	lb.	lb.	lb.	
Corn and cob meal	1200	1335	1335	
Soybean oil meal	150	15	15	
Urea		21		
Dicyandiamide			13.5	
Iodized salt	14	14	14	
Steamed bone meal	28	28	28	
Vitamin A and D supplement, gm.	600	600	600	
Total	1393.0	1414.0	1406.5	
	Proximate analysis, %			Hay
Dry matter	90.9	91.1	91.0	92.5
Crude protein	13.0	13.1	13.4	6.2
Ether extract	3.2	3.5	3.9	2.0
Crude fiber	7.4	7.6	7.5	33.6
N-free extract	63.0	63.1	62.5	44.0
Ash	4.3	3.8	3.7	6.7

Group C, dicyandiamide as a nitrogen extender in the concentrate mixture. Urea and dicyandiamide supplied one-third of the nitrogen in the concentrate mixtures. All cows were fed the control grain mixture for the first 30 days of the lactation. Proximate analyses of the hay and concentrate mixtures were conducted according to standard AOAC methods (1945).

All cows were fed hay and grain at a level of 100 to 110% of Morrison's (1946) minimum TDN (total digestible nutrient) standards for milk production and body maintenance, but only 90 to 100% of Morrison's minimum protein standards. Adjustments in the amount of

concentrates fed were made at four-week intervals in accordance with changes in milk production of each individual cow.

Daily milk production was recorded and two-day composite milk samples were taken once a week for butterfat analysis. Body weights were recorded on three consecutive days at the beginning of the experiment and every four weeks thereafter. Milk and blood urea nitrogen values were determined for each cow once a month according to the method of Van Slyke and Cullen (1914). Three cows from each group were used in digestion trials employing the chromic oxide technique. The trials were conducted every 2 months during the lactation. Fifteen grams of chromic oxide were administered once daily during and for 10 days preceding the collection period. Grab samples of feces were taken daily at 6:00 a.m. and 4:00 p.m. for five consecutive days.

Beginning on the 171st day of lactation one-half of the cows in each group were fed enough corn starch to insure a TDN intake of 110% of Morrison's standards (1946). This was done to prevent further body weight losses and to check a possible energy deficiency due to the poor quality of hay being fed.

Results and Discussion

The composition and chemical analysis of the rations used in this study are shown in table 1. All of the concentrate mixtures were supplemented with vitamin A and D to guard against a possible deficiency of vitamin A since analysis of the hay indicated a very low carotene content. Vitamin D was included only because it happened to be included in the supplement used. The crude protein and fibers content of the timothy hay indicated that it was only medium in nutritive value even though it was graded U.S. No. 1.

Data collected in this experiment concerning milk production and body weight changes are presented in table 2 and figures 1 and 2. One cow in both the soybean oil meal and the urea groups went dry after the 196th-day of the experimental period or 226th day of lactation. Due to this fact, in the presentation and analysis of the data, the first 196 days of the experimental period rather than the entire lactation was used as the major basis of comparison.

Figure 1 shows the average daily 4% FCM (fat corrected milk) production by 4-week periods. The average daily milk production at the beginning and end of the 196-day period was 35.3 and 18.5 lb. for Group A, 35.9 and 14.4 lb. for Group B and 36.2 and 15.5 for Group C. The milk

production of the cows fed the two rations containing the non-protein nitrogen compounds remained slightly below that of the control group during the entire experimental period. The production of the cows fed the urea-containing ration remained at a slightly higher level than the cows in Group C although they were essentially the same at the end of the period. The average daily FCM production during the entire 196-day period was 24.4, 22.3, and 22.2 lb. for Groups A, B, and C, respectively. These differences were not statistically significant using the analysis of covariance (Snedecor, 1946).

TABLE 2. EFFECT OF THE VARIOUS RATIONS ON THE AVERAGE PRODUCTION OF 4 PERCENT FAT-CORRECTED MILK, BODY WEIGHT CHANGES AND BLOOD AND MILK UREA NITROGEN VALUES

	Rations		
	A	B	C
Total length of lactation (days)	280	281	294
Total FCM production during entire lactation (lb./cow)	6727	6051	6135
Total FCM production after 30-day preliminary period (lb./cow)	5735	5151	5240
Daily FCM production during 196-day period (lb./cow)	24.4	22.3	22.2
Gain or loss in body weight during entire lactation (lb./cow)	+42	+2	−21
Gain or loss in body weight during 196-day exp. period (lb./cow)	+3	−28	−86
Blood urea nitrogen (mg./ml.)	6.30	6.88	4.07
Milk urea nitrogen (mg./ml.)	5.79	6.60	3.85
Average days pregnant during experiment	178	186	187

Data in table 2 show the milk production for the entire lactation as well as the 196-day experimental period. The milk production value for both the entire lactation and the entire lactation minus the 30-day preliminary period were in the same order as milk production during the 196-day experimental period. Cows fed Ration C produced slightly more milk on a lactation basis than cows fed Ration B due to a slightly longer lactation. Analysis of variance (Snedecor, 1946) showed no significant difference between rations.

Weight data presented in figure 2 for the 196-day experimental period shows greater differences between rations than was observed for milk production. The body weight of cows in Groups A and B remained almost the same for the first 12 weeks of the experimental period or the first 5 months of the lactation. Thereafter, the cows in the control group

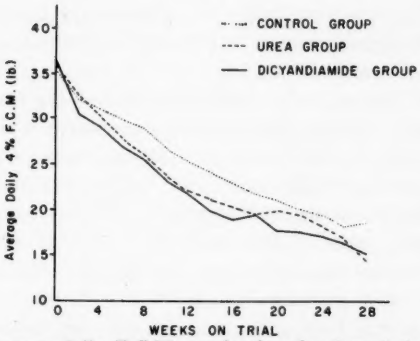

Figure 1. Average daily F.C.M. production, by 2-week intervals, during the first 196 days of the experimental period (beginning 30 days after calving). Eight cows are included in each group.

gained slightly in body weight, whereas the cows in Group B declined sharply in body weight between the 12th and 20th weeks and then increased in weight during the last 8 weeks of the trial. The cows in Group C declined sharply in body weight from the beginning of the experiment until the 20th week. Thereafter a slight increase in body weight occurred. The average body weight losses during the 196-day period for the urea and dicyandiamide groups were 28 and 86 lb. respectively, whereas the control cows gained 3 lb. during this same period. The difference in body weight changes between the control and

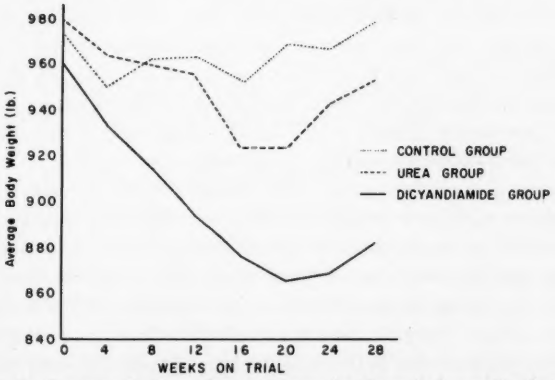

Figure 2. Average body weight change, by 4-week intervals during the first 196 days of the experimental period (beginning 30 days after calving). Eight cows are included in each group.

dicyandiamide groups were highly significant at the 1% level of probability. As shown in table 2, most of the body weight losses were regained before the end of the lactation.

Owing to the general body weight losses during the first 20 weeks of the trial, Group C in particular, enough corn starch was added to the ration of four cows in each group to insure an intake of at least 110% of Morrison's minimum TDN standards. Before this was done it became difficult, owing to declining milk production and low hay consumption, to keep the energy intake of the cows above and the protein intake below Morrison's minimum standards. Thus, on the 141st day of the experimental period, starch was added to the ration of 2 Jersey and 2 Holstein cows in each group. During the next 56 days the starch-fed cows in Groups A, B, and C gained in weight an average of 38.0, 46.5, and 1.8 lb. per cow, respectively. The cows that were not fed starch in Groups A, B, and C gained an average of 8.6, 8.8 and 32.8 lb. per cow, respectively. All starch-fed cows gained in weight an average of 28.8 lb. and the cows not fed starch 16.7 lb. during this period. These data indicate that the addition of extra energy in the form of starch improved the weight gains of cows on rations A and B. The effect of starch on the weight gains of cows on ration C is confusing, since there seems to be no explanation of why these cows gained more when starch was not included.

Milk and blood urea nitrogen values as shown in table 2 were determined for each cow once each month. Relatively low values were obtained on all cows, probably indicating that all rations were marginal in respect to protein intake (Davis *et al.*, 1950). The values for the cows fed the soybean oil mean and urea rations for both blood and milk were significantly higher (1% level) than the values for cows fed the ration containing dicyandiamide. This observation confirms earlier observations at this station (Davis, *et al.*, 1950) indicating that dicyandiamide was not being efficiently utilized by lactating dairy cows.

The average coefficients of apparent digestibility of the various rations are shown in table 3. It should be pointed out that these coefficients are for the entire ration, not just the concentrate mixtures. The average coefficients for Rations A and B were very similar but the average coefficients for Ration C were lower for all nutrients with the exception of ether extract. None of these differences, however, were statistically significant due probably to the small number of cows used and the variation between cows.

Only minor differences in feed consumption existed between rations

with the hay consumption being 18.5, 18.0 and 16.8 lb. per cow daily for Groups A, B, and C, respectively. The concentrate consumption in the same order was 11, 9, 10.8 and 11.5 lb. per cow daily.

All cows were fed a normal herd ration after going off experiment and all freshened with normal calves. No unusual breeding troubles or calving difficulties were encountered.

The milk production of all cows in this experiment was relatively low but it should be remembered that only minimum amounts of protein were fed and the hay was of necessity low in quality. Data obtained in this study indicate that the non-protein nitrogen compound, dicyandiamide, was not utilized as well as either urea or soybean oil meal. The

TABLE 3. THE AVERAGE COEFFICIENTS OF APPARENT DIGESTIBILITY OF THE RATIONS FED

Ration	Dry matter	Crude protein	Ether extract	Crude fiber	N-free extract
	%	%	%	%	%
A, Control	51.0	40.1	43.0	44.4	60.1
B, Urea	50.2	39.2	42.5	45.8	57.5
C, Dicyandiamide	41.3	34.8	42.9	28.5	51.3

pattern of milk production and body weight changes of cows fed the ration containing dicyandiamide were similar to those observed by Hills *et al.* (1922) of cows fed a subnormal protein ration for several lactations. Hills *et al.* (1922) observed that lactating cows fed low-protein rations maintained milk production even though they showed losses in body weight.

Studies are in progress using fistulated dairy steers to determine the extent of dicyandiamide utilization and the causes of its inability to be used as a source of nitrogen by lactating dairy cows.

Summary

Twenty-four cows were used in a lactation study to evaluate soybean oil meal, urea and dicyandiamide as nitrogen sources in low-protein concentrate mixtures. Each nitrogen source supplied approximately one-third of the nitrogen in the concentrate mixture. All cows were limited to a protein inake of 90 to 100% of Morrison's minimum protein standards. A medium-quality timothy hay was fed as the sole roughage.

No significant differences in milk production were observed on a lactation basis or during a comparison period of 196-days in length

beginning on the 30th day of lactation. The average daily milk yields during this period were 24.4, 22.3 and 22.2 lb. per cow daily for the soybean oil meal, urea and dicyandiamide rations, respectively.

Significant differences were observed between rations in respect to body weight losses and blood and milk urea nitrogen levels. During the 196-day period the cows fed the ration containing soybean oil meal averaged 3 lb. gain in weight, whereas the cows in the urea group lost 28 lb. and those fed the dicyandiamide ration lost 86 lb. The difference between the soybean oil meal and dicyandiamide rations was highly significant. Cows fed the soybean oil meal and urea rations had significantly higher blood and milk urea nitrogen values than cows fed the dicyandiamide ration.

No significant differences in coefficients of apparent digestibility were observed between the rations, but coefficients of all nutrients with the exception of ether extract were lower for the dicyandiamide ration than the other two rations.

Data obtained in this study show that the non-protein nitrogen compound, dicyandiamide, was not used efficiently by dairy cows. Studies are in progress to study this problem further.

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THE EFFECT OF VARYING LEVELS OF PROTEIN AND CERELOSE ON THE UTILIZATION OF MATURE TIMOTHY HAY BY SHEEP [1]

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VAST quantities of low quality roughage are available for livestock feeding. Supplementation of these low grade roughages has culminated in a new concept of ruminant nutrition which emphasizes optimum feeding of the rumen microorganisms. Beeson and Perry (1952) have shown that corn cobs when properly supplemented are an efficient source of energy for beef cattle. Burroughs *et al.* (1949a, 1949b) and Gallup *et al.* (1946, 1952, 1954) have shown that roughage utilization can be improved by the addition of nitrogen.

The role of a readily available carbohydrate for efficient roughage digestion is not clear. *In vitro* studies (Arias *et al.*, 1951) have shown that rumen microorganisms require a source of readily available energy for a maximum rate of cellulose digestion. However, *in vivo* studies have shown that the addition of readily available carbohydrate will decrease crude fiber digestion (Mitchell *et al.*, 1940; Hamilton, 1942; Briggs and Heller, 1943; Burroughs *et al.*, 1949c, Fontenot *et al.*, 1955).

The present investigation was initiated therefore, to determine by metabolism procedures (1) the effect of varied levels of protein and a readily available carbohydrate (cerelose) on the utilization of mature timothy hay and (2) the effect of cerelose on the utilization of protein in rations of varied protein content.

Experimental

A series of three metabolism trials was conducted with 18 crossbred wether lambs. These whethers, which averaged about 75 lb. each, were divided into nine groups of two whethers each on the basis of weight. They were randomly allotted in a 3 x 3 factorial design. The wethers were stanchioned in metabolism cages similar to those described by Briggs and Gallup (1949) and were housed in a steam-heated metabo-

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

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lism room. The temperature of the metabolism room was maintained at approximately 75° F. to reduce the variability of environmental temperature from trial to trial. The wethers were sheared prior to each trial, and after they had become adjusted to their rations a 10-day preliminary period was followed immediately by a 10-day collection period. After each trial the wethers were given a 30-day rest period and fed alfalfa hay free choice before another trial was started. Average daily feed intake is shown in table 1.

TABLE 1. AVERAGE DAILY RATIONS AND THEIR CHEMICAL COMPOSITIONS

Items	Ration numbers								
	1	2	3	4	5	6	7	8	9
Ration constituent, gm.									
Timothy hay	650	650	650	650	650	650	650	650	650
Soybean oil meal	9	9	9	73	73	73	143	143	143
Cerelose	0	25	50	0	25	50	0	25	50
$CaHPO_4$	5	5	5	5	5	5	5	5	5
NaCl	9	9	9	9	9	9	9	9	9
A and D oil[a]	2	2	2	2	2	2	2	2	2
Dry matter, %	92.50	92.43	93.02	92.30	92.55	92.79	92.09	92.34	92.57
Percentage composition of dry matter									
Organic matter	92.50	93.28	93.20	92.70	93.26	93.19	92.78	93.00	93.23
Crude protein	7.11	6.86	6.58	11.18	10.79	10.42	14.54	14.07	13.62
Ether extract	2.25	2.17	2.09	2.19	2.11	2.04	2.12	2.03	1.99
Crude fiber	37.85	36.52	35.04	35.19	33.94	32.78	32.92	31.85	30.84
Nitrogen-free extract	45.29	47.73	49.49	44.14	46.42	47.95	43.20	45.05	46.82
Ash	7.50	6.72	6.80	7.30	6.74	6.81	7.22	7.00	6.73
Gross energy calories per gm. dry matter	4449	4452	4419	4476	4462	4451	4502	4489	4476

[a] A concentrated cod liver oil with a potency of 1800 U.S.P. units of Vitamin A and 180 U.S.P. units of Vitamin D per gram.

Soybean meal was added to rations, 1, 4 and 7 to raise the crude protein content ($N \times 6.25$) to approximately 6.9, 10.9 and 13.6%, respectively. The average cerelose addition to rations 2, 5 and 8 was 3.3% and to rations 3, 6 and 9 it was 6.2%.

The wethers were fed twice daily, receiving one-half of the ration at each feeding. The soybean meal, salt, di-calcium phosphate, and vitamin A and D oil were mixed in a mechanical mixer prior to each trial in sufficient quantity for 20 days of feeding and then stored in closed metal containers. The timothy hay, which was chopped into approximately 2-inch lengths before each feeding, was placed in the bottom of the feed boxes, and the concentratese were sprinkled over the chopped hay.

The feces were collected once daily, weighed and a 10% aliquot was taken. During the collection period these fecal samples were refrigerated

in airtight jars to which a small amount of thymol had been added. At the completion of the collection period the samples were dried in a forced-air oven at 68–73° C. for approximately 72 hours. The samples were allowed to equilibrate with air and then ground. The daily urine excretion, which was collected in jars containing acid (HCl 1:1), was transferred quantitatively to a volumetric flask and brought to a constant volume by the addition of water. After thorough mixing, an aliquot was stored until completion of the trial when the individual aliquots were mixed and sampled for analysis. The feed, feces and urine

TABLE 2. DIGESTIBILITY OF THE RATIONS, AND NITROGEN BALANCE [a]

Ration	Digestibility							Daily nitrogen balance
	Dry matter	Organic matter	Crude protein	Ether extract	Crude fiber	N.F.E.	Energy	
	%	%	%	%	%	%	%	gm.
1	52.2	52.7	50.7	46.9	48.1	57.4	49.3	−0.60
2	53.8	54.1	50.8	54.2	48.1	59.4	50.6	−0.74
3	53.8	54.4	47.7	49.7	45.4	61.6	51.0	−0.33
4	55.1	55.8	69.1	50.4	47.4	58.9	52.5	−0.11
5	56.6	57.3	67.9	48.5	48.4	61.8	54.5	+0.48
6	57.0	57.7	66.0	45.9	46.2	64.2	54.7	+0.34
7	59.3	59.8	76.1	56.0	50.2	62.2	57.5	+0.22
8	58.7	59.5	75.0	46.8	48.1	63.3	56.8	+0.51
9	59.8	60.9	73.8	53.6	47.4	65.6	57.9	+0.90

[a] Each value represents an average obtained with six wethers.

were analyzed by methods of the A.O.A.C. (950). The gross energy of the feed and feces was determined with a Parr Oxy-bomb calorimeter equipped with an adiabatic jacket. The data were analyzed statistically by analysis of variance (Snedecor, 1946).

Results and Discussion

The average apparent digestion coefficients for each ration are presented in table 2. An increase in the percentage of protein from 6.9 in ration 1 to 10.9 in ration 4 increased significantly the apparent digestibility of dry matter, organic matter, protein and energy ($P<0.01$) and nitrogen-free extract ($P<0.05$). A further increase in protein to 13.6% in ration 7 increased the apparent digestibility of dry matter, organic matter, protein, nitrogen-free extract and energy over the lower level of protein (compare rations 1 and 4 vs. 7). These results are

statistically significant ($P<0.01$). The level of protein had no significant effect on crude fiber digestibility.

The addition of either 3.3% or 6.2% cerelose at all levels of protein had no significant effect on the digestibility of dry matter, organic matter and energy. However, with each addition the digestibility of nitrogen-free extract was increased significantly ($P<0.01$). The addition of 3.3% cerelose at all levels of protein had no significant effect on the digestibility of protein, but 6.2% of cerelose significantly decreased protein digestibility ($P<0.01$) below that of the rations containing zero and 3.3% of cerelose. Hamilton (1942) observed that glucose decreased the apparent digestibility of total nitrogen when added to a ration containing timothy hay as the roughage. The decrease in protein digestibility due to added cerelose can be explained in part by an increased output of metabolic nitrogen (Harris and Mitchell, 1941). However, an increased nitrogen retention due to the addition of cerelose was more indicative of the effect of cerelose on nitrogen utilization than the apparent digestibility of protein which gave no indication as to gain or loss of nitrogen to the body.

The wethers that received the low protein rations in the presence of cerelose were in negative nitrogen balance, which indicates they were on an energy- and protein-deficient ration. When the percentage of protein was increased to 10.9% the wethers were still in negative nitrogen balance, but the addition of 3.3% cerelose to this ration resulted in a positive nitrogen balance. Differences in nitrogen retention due to cerelose addition were not statistically significant. Ration 4 compared with ration 5 suggests a "protein sparing" action of carbohydrate. An increase in protein from 6.9 (ration 1) to 10.9% (ration 4) resulted in a highly significant ($P<0.01$) increase in nitrogen retention. A further increase in protein (ration 7) had no significant effect on nitrogen retention over the 10.9% level (ration 4), but the difference between the 6.9 (ration 1) and the 13.6 (ration 7) % levels was highly significant.

The addition of cerelose at low levels had no signficant effect on crude fiber digestibility. However, the higher levels of added cerelose effected a definite trend toward a decrease in crude fiber digestion. Apparently the difference between these results and the results of other workers (Hamilton, 1942; Mitchell *et al.*, 1940; Fontenot *et al.*, 1955) is due to the level of readily available carbohydrate added to the ration.

An increase in protein from 6.5% (ration 1) to 13.6% (ration 7) failed to improve crude fiber digestion. Likewise, Head (1953) failed to show any improvement in roughage digestion by additions of protein and starch. Williams *et al.* (1953) suggested that the nitrogen require-

ment for bacterial proliferation and function in the rumen is very low. The data presented in the present report indicate that the protein required for efficient utilization of timothy hay by rumen microorganisms was adequate at the 6.5% level but that this level was inadequate to maintain nitrogen equilibrium in the wethers. This is in agreement with the work of Burroughs *et al.* (1950) who suggested that the minimum protein requirement for efficient roughage digestion in cattle was the nitrogen requirement for the growth of rumen microorganisms directly involved in roughage digestion.

Various roughages differ widely in chemical composition and digestibility. Forbes and Garrigus (1949) have suggested that lignin may be an important factor in roughage digestion. Unpublished data at this station show that the crude fiber fraction of corn cobs is more digestible than the crude fiber fraction of timothy hay or cottonseed hulls (Grainger and Thompson, 1955). Further unpublished data show that alfalfa silage on the dry basis contains about 33% more lignin than corn cobs (Grainger and Thompson, 1954).

Summary

A series of three metabolism trials was conducted with 18 wether lambs, weighing about 75 lb. each, in a 3 x 3 factorial design. Low quality timothy hay was supplemented with increasing amounts of soybean meal to raise the protein content of the ration to approximately 6.9, 10.9 and 13.6%. Cerelose was added in amounts of 0, 3.3 and 6.2% of the ration. The addition of soybean meal resulted in a highly significant increase in apparent digestibility of dry matter, organic matter, protein, nitrogen-free extract and energy, and in a highly significant increase in nitrogen retention.

The addition of cerelose produced a highly significant increase in digestibility of nitrogen-free extract but did not significantly affect the apparent digestibility of dry matter, organic matter, crude fiber or energy. The high level of cerelose additions decreased the digsetibility of protein at all levels of protein studied.

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THE INFLUENCE OF FAT, CHLORTETRACYCLINE, AND STILBESTROL ON VITAMIN A AND CAROTENE STORAGE IN THE LIVER OF BEEF STEERS [1]

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IN the arid western states vitamin A deficiency has probably resulted in greater economic losses to the beef industry than any other single dietary factor. Today, when various feed supplements are being fed to cattle, it is of practical as well as fundamental interest that vitamin A-carotene metabolism be investigated relative to various supplemental feedings. The addition of inedible fats as a supplement to ruminant rations has resulted in variable degrees of beneficial effects.

Ahmad (1931) reported that rats excreted as much as 90% of the dietary carotene when they were fed a fat-free diet while 10% added fat resulted in optimum utilization. Burns *et al.* (1951) stated that beta-carotene and vitamin A were better utilized by rats fed a diet containing 5% lard than by rats fed a diet deficient in fat. Russell *et al.* (1942) reported similar results with hens.

Since carotene and vitamin A are both fat soluble, it has been postulated that the level of dietary fat influences their absorption. The normal ration of ruminants is low in fat. Therefore, if dietary fat were essential for optimum carotene and vitamin A absorption, the ruminant might be inefficient in the utilization of this vitamin.

Antibiotics have been shown to have a "sparing effect" on B-vitamin requirements. Also, increasing interest in vitamin A, carotene and antibiotic supplementation is evident. Reports by Coates *et al.* (1952) and Burgess *et al.* (1951) with chicks fed antibiotics indicate an increased liver content of vitamin A, but Coates *et al.* (1952) indicated an increase in vitamin A only in the presence of increased growth. High (1955) reported a vitamin A "sparing effect" when carotene was fed

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to rats but not when performed vitamin A was administered. Antibiotics are becoming an increasingly important supplement to cattle. Consequently, the antibiotic influence on vitamin A and carotene nutrition needs further elucidation.

Stilbestrol has recently become common feed supplement for cattle. Results reported by Crook and El-Marsafy (1954) and Palmer and Eckles (1914) suggest that the level and type of blood proteins may

TABLE 1. COMPOSITION OF STEER RATIONS

Treatments	Straw	Alfalfa	Stilbestrol	Chlor-tetracycline	Fat	Grain mixture
	%	%	mg./lb.	mg./lb.	%	%
(1)	50					50
a		50				50
s	50		.45			50
as		50	.45			50
c	50			5.0		50
ac		50		5.0		50
sc	50		.45	5.0		50
asc		50	.45	5.0		50
f	82				7	11
af		82			7	11
sf	82		.45		7	11
asf		82	.45		7	11
cf	82			5.0	7	11
acf		82		5.0	7	11
scf	82		.45	5.0	7	11
ascf		82	.45	5.0	7	11

(1) Straw, (a) alfalfa, (s) stilbestrol, (c) chlortetracycline, (f) fat.

influence the absorption and transportation of vitamin A and carotene. These results indicate that albumin, alpha-, and beta-globulin are the principal proteins involved. Wayman and Asdell (1951) reported that estrogen increased beta- and gamma-globulin levels in cattle.

Because of the above relationships of fat, chlortetracycline and stilbestrol to vitamin A and/or carotene metabolism, the study reported herein was undertaken.

Procedure

The experimental animals consisted of 48 yearling Hereford steers with an initial mean weight of 600 lb. The steers were divided into 16 lots of 3 animals each and treated in the manner shown in table 1 for 183 days. Three percent of sodium bentonite was added to all rations to

provide a more desirable physical consistency to the pelleted feed. A 2^4 factorial design was employed in which chlortetracycline (5 mg. per/lb. of feed), stilbestrol (0.45 mg. per/lb. of feed), inedible animal fat (bleachable fancy tallow as 7.0% of the ration), and roughages (alfalfa and wheat straw) were the variables.

Liver biopsies were taken at 0, 72, and 183 days, (Erwin *et al.*, 1956b) and subjected to vitamin A and carotene determinations (Gallup and Hoefer, 1946).

TABLE 2. LIVER VITAMIN A AND CAROTENE STORAGE
(Treatment Effects)

Treatment effects	Carotene (mcg. per 100 gm.)		Vitamin A (mcg. per gm.)	
	72 days	183 days	72 days	183 days
Mean	−304	−448	−26.5	−37.5
A	345**	366**	15.5	33.8**
S	68	11	−2.1	−0.1
AS	119	90	4.6	−1.1
C	127	143	2.2	5.4
AC	120	137	−1.0	0.6
SC	−132	−161	−4.1	−0.9
ASC	−38	22	−3.5	−0.08
F	286**	362**	18.4	11.2
AF	124	186	5.3	9.8
SF	103	62	9.6	4.8
ASF	4	−54	−4.9	−3.0
CF	−45	−55	4.2	5.1
ACF	−109	−61	−2.3	1.7
SCF	−149	−157	−3.4	3.4
ASCF	82	59	−4.4	−5.3
$LSD_{.05}$	188	192	19.7	23.2
$LSD_{.01}$	252	258	26.4	31.2

(A) Alfalfa, (S) stilbestrol, (C) chlortetracycline, (F) fat.
** $P<.01$.

All rations were analyzed for carotene three times during the experimental period by the methods approved by the A.O.A.C. Treatments 1–4 and 5–8 were found to contain 15.3 and 13.3 mg. of carotene per pound of rations, respectively. Rations 9–16 did not contain a measurable amount of carotene. Data were analyzed as a 2^n factorial series as described by Kempthorne (1952).

Results and Discussion

No significant difference was found in liver carotene from steers fed chlortetracycline with or without a dietary carotene source (table

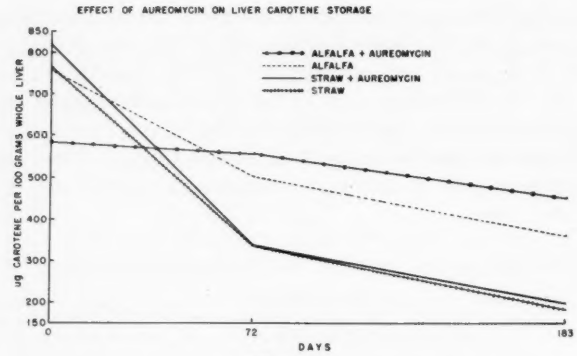

Figure 1.

2 and figure 1). Reports (Erwin *et al.*, 1956a) revealed that chlortetracycline decreased fat digestion. Results in table 2 indicate a possible interaction (non-significant) between roughage (dietary carotene) and fat. Increased fat produced a highly significant increase in carotene retention whether it was fed with or without a dietary source of carotene (figure 2). Reports from New Zealand (McGillivray, 1951) indicated an apparent intestinal synthesis of carotene in sheep. If such occurs in cattle, fat possibly increases the absorption of synthesized carotene or its effect on liver carotene storage might be mediated by some mechanism other than absorption. However, an independent absorption is

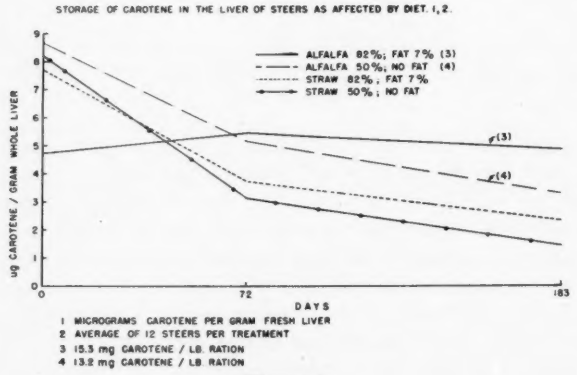

Figure 2.

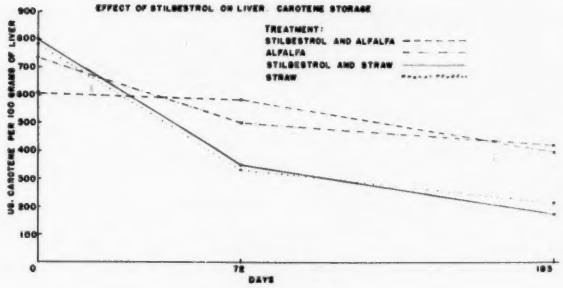

Figure 3.

indicated by Raper (1950) who studied the influence of added fat on carotene utilization in beef cattle. He found that 5.5% of dietary fat did not influence carotene storage but did result in higher plasma carotene values.

The addition of stilbestrol to the diets of steers resulted in no influence on carotene (figure 3) or vitamin A (figure 4) storage in steers' livers (table 2). Gardiner *et al.* (1952) reported an elevation in plasma vitamin A in estrogenized immature pullets. The findings herein do not discount the possibility that stilbestrol could increase absorption, or that a higher level of dietary or implanted stilbestrol may influence the storage of carotene and/or vitamin A. These results, however, indicate that stilbestrol fed to steers at the rate of 0.45 mg. per lb. of ration neither increases the conversion of carotene to vitamin A nor results in any difference relative to the liver retention of this vitamin.

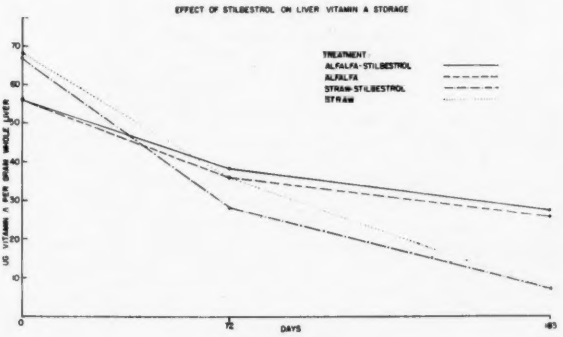

Figure 4.

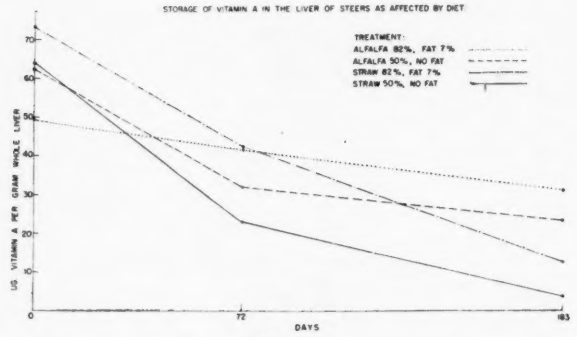

Figure 5.

Table 2 shows the influence of fat (figure 5) and chlortetracycline (figure 6), with and without carotene, on liver vitamin A retention by steers. Although fat had a highly significant influence on carotene retention, no significant difference in liver vitamin A was found. These findings are substantiated by those of Raper (1950). Results reported by High (1955) indicated that chlortetracycline administration to rats accelerated carotene conversion to vitamin A. Neither dietary fat nor chlortetracycline affected vitamin A storage.

Summary

The effect of dietary chlortetracycline, stilbestrol, and fat on liver storage of carotene and vitamin A in steers indicates that:

1. Feeding fat resulted in a highly significant increase of carotene

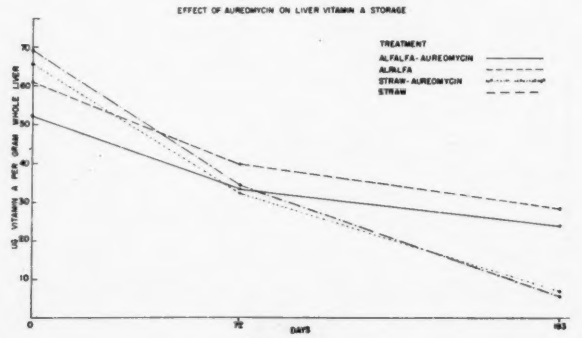

Figure 6.

retention, but not vitamin A, in the liver regardless of carotene levels used.

2. Neither stilbestrol nor chlortetracycline influenced liver carotene or vitamin A storage.

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N,N^1-DIPHENYL-P-PHENYLENEDIAMINE IN THE PREVENTION OF VITAMIN E DEFICIENCY IN THE LAMB

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IT has been demonstrated that N,N^1-diphenyl-p-phenylenediamine (dppd) is effective in preventing encephalomalacia in the chick (Singsen *et al.*, 1955) and low hatchability of turkey eggs (Jensen *et al.*, 1956) produced by feeding a tocopherol-low diet. Inclusion of this compound in the diet also has been shown to increase the vitamin A and carotenoid levels in the blood plasma and liver (Potter *et al.*, 1956; Monson *et al.*, 1955). Johnson and Goodyear (1955) have reported that dppd is capable of preventing resorption-gestation in female rats maintained continuously on a tocopherol-free diet from weaning age, but that the protective effect disappears during the second or third reproductive cycles. They also have found that dppd fails to regenerate vitamin E-deficient female rats, thereby indicating that the vitamin is specific for some essential function in metabolism. However, Draper *et al.* (1956) have observed that the quantity of alpha-tocopherol required for regeneration of deficient females is markedly decreased in the presence of dppd in the curative diet.

These results support the popular theory that tocopherols play a specific role in metabolism which cannot be assumed by other compounds, but that part of the dietary requirement for vitamin E represents a requirement for self-preservation or other antioxidation reactions in which the vitamin is replaceable with certain other antioxidants.

The present study was designed to determine whether dppd is capable of preventing vitamin E deficiency in lambs fed a tocopherol-free artificial milk diet. A preliminary report of the experiment has appeared (Draper and Johnson, 1955).

Experimental

The experimental animals were twenty lambs, one to three day old, obtained from the University flock [2] and local breeders. They were fed *ad libitum* a basal diet similar to that described earlier (Draper *et al.*,

[1] This project was supported in part by a grant from Armour and Company, by a gift of vitamins from Merck and Co., Inc., and by a supply of N,N^1-diphenyl-p-phenylenediamine from B. F. Goodrich Chemical Company.
[2] Courtesy of U. S. Garrigus.

1952) except that the tocopherol-free lard was incorporated at a level of 28% and cerelose was increased to 36% of the dry matter content. The diet contained 16% solids.

The lambs were allotted to five groups of four each. Dppd was added daily in ethanol solution to the diet of three groups at rates calculated to provide 0.001%, 0.025% and 0.10% of the dry matter intake, respectively. The lowest level was chosen as a result of previous experience with rats which indicated that dppd was toxic when fed at the two higher levels over an extended period of time (Draper *et al.*, 1956). The two remaining groups were given, respectively, the basal diet alone or with a vitamin E supplement (50 mg. α-tocopherol per lb. body weight per week).

Results

Two criteria of vitamin E deficiency were employed, namely, the occurrence of clinical symptoms of "stiff lamb disease" and histological degeneration of skeletal and cardiac muscle. Detailed descriptions of the symptoms and lesion have been given elsewhere (Madsen *et al.*, 1935; Metzger and Hagan, 1927). The lambs were maintained on the experimental diets for a period of 7 weeks or until death or clinical symptoms occurred. The tissue samples were placed in FAA fixative (formalin-acetic acid-alcohol) for 24 hours and were preserved in 70% ethanol. Slices were mounted in paraffin and stained with hematoxylin and eosin.

The performance of the various groups may be summarized by treatments as follows:

Group 1. Basal diet. Two lambs developed muscular dystrophy after 27 and 34 days, respectively, and one died suddenly after 37 days. One animal survived the 7-week experimental period. Upon histological examination, the tissues from all the lambs exhibited local cellular degeneration and nuclear proliferation as described by several other workers for vitamin E-deficient animals.

Group 2. 0.001% dppd. All animals developed "stiff lamb disease", characterized chiefly by muscular weakness of the hind legs, or died suddenly during the fifth week. The histological appearance of the tissues was similar to that of the negative controls. Hence this level of dppd exerted no apparent effect on the course of vitamin E deficiency.

Group 3. 0.025% dppd. Three members of this group survived the experiment without exhibiting any clinical symptoms of vitamin E de-

ficiency. The fourth died suddenly after 41 days, having gained 0.57 lb. per day. The histological examination indicated slight proliferation of nuclei in local areas; otherwise the tissues appeared normal. The single fatality may have been a consequence of the rapid rate of growth which may be presumed to have increased the vitamin E requirement of this animal.

Group 4. 0.10% dppd. All the animals receiving this level of dppd appeared in normal condition, clinically and histologically, at the end of the experiment. Average daily gains for the four lambs were 0.29, 0.30, 0.33 and 0.49 lb. per day.

Group 5. Alpha tocopherol. No evidence of vitamin E deficiency or other manifestations of malnutrition were observed.

The growth rate was not affected by the various treatments imposed, and group averages ranged from 0.22 to 0.35 lb. per day.

Discussion

The foregoing results demonstrate that dppd is capable of preventing muscular dystrophy in lambs receiving a vitamin E-deficient diet, and that, under the conditions imposed, from 0.025% to 0.10% of the dry matter intake is effective. The 0.025% level appears to have been somewhat suboptimal for the complete prevention of muscle degeneration. It should be anticipated that under other experimental conditions, with particular reference to the dietary concentration of unsaturated fatty acids, the effective amount of dppd would be significantly different. The milk of the ewe is substantially higher in fat than the diet used in this study, but the proportion of unsaturated fatty acids is lower, so that the concentration of monoethenoid and polyethenoid acids per unit of dry matter is roughly comparable. To the extent that the concentration of unsaturated fatty acids in the diet contributes to the development of "stiff lamb disease" it may be surmised that 0.1% dppd might approximate the amount effective for lambs receiving vitamin E-low natural milk.

Summary

Newborn lambs were maintained on an artificial milk diet containing tocopherol-free lard as a source of fat. The effectiveness of N,N^1-diphenyl-p-phenylenediamine (dppd) in preventing the occurrence of clinical and histological signs of muscular dystrophy was determined. Administration of dppd at a level equivalent to 0.10% of the dry matter

content of the diet completely prevented the appearance of vitamin E deficiency. A level of 0.025% was found to be slightly inadequate and 0.001% was ineffective.

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NUTRIENT CONSUMPTION AND UTILIZATION FROM ALFALFA PASTURE, SOILAGE, AND HAY

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IN earlier reports from this station (Ittner *et al.*, 1954; Meyer *et al.*, 1956) data have been presented comparing the beef production from alfalfa pasture, soilage, and hay. Studies have also been made in which the chromogen technique (Reid *et al.*, 1952) has been compared to a pre- and post-grazing clipping method for measuring the dry matter intake of grazing animals. By extension of the chromogen technique it has been possible to determine the total digestible nutrient (TDN) intake of the grazing animals (Lofgreen and Meyer, 1956). The TDN intake thus determined has been compared to that obtained by the pre- and post-grazing clipping method. Observations were also made of the efficiency with which the TDN consumed was converted to gain when steers were fed alfalfa by the various methods mentioned above. It is the purpose of this paper to present the results of the studies on nutrient consumption determined by the two methods and the efficiency with which the consumed nutrients are converted to gain.

Experimental

Forty head of good to choice feeder steers were randomly divided into four lots of ten head each. One lot was assigned to each of the following treatments: five- or six-day rotational grazing, strip grazing, hay feeding, and soiling. A uniform alfalfa field was selected and divided into three blocks with all treatments randomized in each block. The details of the field layout, the management of the fields, and the feeding procedure have been described in detail in an earlier report (Meyer *et al.*, 1956).

During the last 100 days of the study three steers in each lot which had earlier been trained to tolerate fecal collection equipment were used to collect total feces. Collections were made for either five or six days beginning four days after entering a new block. A total of nine collections were made on each steer. Feces thus collected were sampled for chromogen, dry matter, and ash analyses. Chromogen analyses were made after stabilizing the acetone extract by exposing it to 800 foot candles of light for 20 minutes. Dry matter consumption was then de-

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termined by use of the regression equation described by Reid *et al.* (1952). TDN consumption was determined by the method proposed by Lofgreen and Meyer (1956) from the digestibility of organic matter.

During the last six collection periods, the dry matter and TDN consumption of the steers on pasture were determined indirectly by clippings made before and after grazing. A small tractor and mower with an attached basket was used to collect the harvested forage which was immediately weighed and dried. The morning steers were to be rotated to a new pasture twelve areas, each measuring 3.5×12.5 feet were clipped from each pasture. A measure was thus obtained of the dry matter per acre available for grazing in each pasture. The day following removal of the animals from the grazed pasture 20 similar areas were clipped and the forage weighed and dried as before. This served as a measure of the dry matter per acre refused by the animals. By difference, therefore, it was possible to calculate the dry matter consumed. This could be checked against the dry matter consumption for the same period as determined by the chromogen technique.

All pre-grazing samples and all post-grazing samples were composited for the six periods and were fed to wethers in digestion trials at the conclusion of the trial. The TDN content of the forage available for grazing and of that refused was then used to calculate the TDN consumption. This could also be compared to the TDN consumption determined from the chromogen technique. An example of the calculation of dry matter and TDN consumption by the pre- and post-grazing clipping method is shown in table 1. Composite samples of the soilage, the hay, and the refused feed were also saved for digestion trials.

For measurement of gains in weight all animals were weighed every 10 or 12 days depending upon which block they were in. All weighings were made after subjecting the animals to a 14-hour shrink without feed or water.

Results and Discussion

The data obtained from the steers fed soilage provide an opportunity to compare the chromogen technique for calculating dry matter consumption with that determined by weighing all feed offered and that refused. Such a comparison is shown in table 2. Even though the values calculated by the chromogen technique are consistently less than those found by subtracting the dry matter weighed back from that fed it is felt that these differences are not unreasonably large. A possible con-

TABLE 1. EXAMPLE OF CALCULATION OF DRY MATTER AND TDN CONSUMPTION FROM ALFALFA FORAGE BY THE CLIPPING METHOD

Dry matter available per acre, lb.[a]	2405
TDN in dry matter, %[b]	55.4
TDN available per acre, lb.	1332
Dry matter refused per acre, lb.[a]	709
TDN in dry matter refused, %[b]	47.5
TDN refused per acre, lb.	337
Consumption per acre:	
Dry matter, lb. (2405–709)	1696
TDN, lb. (1332–337)	995
Acres used	0.89
Consumption per lot:	
Dry matter, lb. (1696×0.89)	1509
TDN, lb. (995×0.89)	886
Steer days	108
Consumption per head per day:	
Dry matter, lb. (1509÷108)	14.0
TDN, lb. (886÷108)	8.2

[a] Determined by pre- and post-grazing sampling.
[b] Determined by digestion trials with wethers on composite pre-grazing and post-grazing samples saved throughout the experiment.

tributing factor to the slightly higher dry matter consumption determined by the difference method is that when the animals were eating it was possible for them to drop some feed outside the feed bunk. This would not appear in the weighback and would thus be measured as feed consumed. The results of this comparison indicate that the chromo-

TABLE 2. COMPARISON OF THE CHROMOGEN METHOD OF DETERMINING DRY MATTER CONSUMPTION WITH THE MEASURED INTAKE OF STEERS FED SOILAGE

		Alfalfa dry matter consumption, lb.			
		Total per lot		Per head per day	
Collection period No.	Steer days	Amount fed minus weighback	Calculated by chromogen method	Amount fed minus weighback	Calculated by chromogen method
1	120	1496	1360	12.5	10.9
2	100	1225	1150	12.3	11.5
3	120	1547	1466	12.9	12.2
4	100	1246	1105	12.5	11.1
5	120	1687	1686	14.1	14.1
6	100	1433	1367	14.3	13.7
7	120	1777	1668	14.8	13.9
8	100	1565	1450	15.7	14.0
9	120	1894	1682	15.8	12.9
Means		1541	1436	13.9	12.9

gen technique as used in this study gives a reasonable estimate of the dry matter intake of animals consuming green alfalfa. The dry matter consumption of the animals grazing alfalfa determined by the chromogen technique can consequently be cited with confidence that the values closely represent the true consumption.

A summary of the comparison of the pre- and post-grazing clipping

TABLE 3. ALFALFA DRY MATTER AND TDN CONSUMPTION OF PASTURE LOTS DETERMINED BY CLIPPING AND CHROMOGEN TECHNIQUES

Collection period No.	Consumption per head per day, lb.			
	Dry matter		TDN	
	Clipping	Chromogen	Clipping	Chromogen
	Rotational grazing			
4	13.6	9.3	8.1	5.3
5	14.1	12.0	8.2	6.7
6	14.3	10.4	8.5	5.9
7	14.1	10.7	8.3	6.3
8	18.3	11.1	10.7	6.5
9	14.7	10.1	8.5	5.5
Means	14.9	10.6	8.7	6.0
	Strip grazing			
4	11.9	7.4	7.1	3.9
5	12.5	9.6	7.4	5.4
6	13.6	9.3	8.1	5.3
7	13.7	9.3	8.1	5.5
8	12.8	9.5	7.5	5.5
9	11.3	9.0	6.8	5.5
Means	12.6	9.0	7.5	5.2

method with the chromogen technique for measuring the dry matter intake of grazing animals is presented in table 3. As a further comparison the TDN determined by the two methods is also shown. It will be noted that the dry matter consumption estimated from the clipping method averaged nearly 40% greater than that estimated by the chromogen technique. Since the chromogen technique gave a good estimation of the dry matter intake with the animals fed soilage it is logical to assume that this method would be satisfactory with the grazing animals. If this is true it must be concluded that the clipping method does not give a good estimate of the dry matter and TDN intake of grazing animals as used in this study. It is felt that the main source of error lies in the difficulty of obtaining an accurate post-grazing sample. Residue remain-

ing after grazing is apparently underestimated because of losses from leaf shattering, trampling, fouling of green forage by droppings, and forage dropped from the mouths of the grazing animals.

It is interesting to note that the average dry matter consumption of the two groups of steers on pasture averaged close to 10 lb. (table 3) while those fed soilage consumed approximately 13 lb. (table 2) as determined by the chromogen technique. The daily gains (shown in table 6), however, are not significantly different. This might lead one

TABLE 4. FECAL DRY MATTER EXCRETION FROM ALFALFA
(lb. per day)

Collection period No.	Rotational grazing	Strip grazing	Soiling
1	2.81	3.28	3.91
2	3.29	2.64	4.00
3	3.17	3.18	4.38
4	3.46	2.76	4.07
5	4.58	3.22	4.97
6	4.00	3.35	4.94
7	3.94	3.20	4.88
8	4.10	3.38	5.11
9	3.99	2.99	4.86
Means	3.71	3.11	4.57

to believe that the chromogen technique was underestimating the intake of the pasture steers and that the clipping method was more accurate. In this regard the fecal dry matter excretion is of interest. Table 4 shows the daily fecal dry matter excretion of the steers in the three groups. It will be noted that the steers fed soilage excreted approximately 30% more fecal dry matter than those on pasture. This must mean that either the steers on soilage consumed more dry matter or that the dry matter digestibility of the soilage was lower than that of the pasture. The dry matter digestibility, determined by the method of Reid *et al.*, (1952) from the chromogen in the feces averaged 59.0% for the pasture and 59.1% for the soilage. Since the dry matter digestibility was the same but the steers on pasture excreted less dry matter it follows, therefore, that their forage consumption was lower than those fed soilage.

The fact that the steers on pasture made as much gain in weight as those fed soilage while consuming less forage is of importance. To explain this it must be assumed that the forage consumed by the

TABLE 5. EXAMPLE OF CALCULATION OF TDN IN ALFALFA FORAGE FROM GAIN IN WEIGHT

Average body weight, lb.	724
Daily gain, lb.	1.73
TDN required for maintenance and gain, lb. per day [a]	10.66
Steer days	912
TDN required per lot, lb.	9722
Oat hay consumed, lb.	4363
TDN in oat hay, lb.[b]	2491
TDN in alfalfa (9722–2491), lb.	7231
Alfalfa dry matter consumed, lb.[c]	9162
TDN in alfalfa, %, dry basis	78.9

[a] Calculated from the formula: $f=0.0553\ W^{2/3}\ (1+0.805g)$ where f=TDN required in pounds per day, W=body weight in pounds and g=daily gain in pounds (Winchester *et al.*, 1953).
[b] Determined by digestion trials on composite hay sample saved throughout the experiment.
[c] Determined by the chromogen technique.

pasture steers had a higher TDN or net energy content even though the dry matter digestibility was the same. The TDN content of the grazed forage was, however, only slightly higher than that in the soilage (table 6). This small difference in TDN content cannot account for the equal gains of the pasture-fed steers on 30% less dry matter intake. The only logical remaining explanation, exclusive of differences in animals, appears to be that the productive value of the TDN in the pasture was higher than that of the soilage. To test this possibility the TDN theoretically required to produce the gain attained by the

TABLE 6. EFFICIENCY OF TDN UTILIZATION FOR GAIN IN WEIGHT

	Rotation grazing	Strip grazing	Soiling	Haying
TDN, percent in forage consumed				
Determined by chromogen technique	57.8	57.7	55.7*	56.9[a]
Calculated from gain in weight	78.9	76.6	60.3*	46.8**
Average daily gain, lb.	1.73	1.54	1.64	1.34*
Daily TDN consumption, lb.[b]	8.7**	8.0**	9.4**	11.1**
Gain per 100 lb. TDN consumed, lb.	20.1	19.3	17.4*	12.1**

[a] Calculated from the digestion trials on the composite samples of hay fed and that refused since the chromogen content of the hay was too low to permit the use of the regression equation to predict digestibility.
[b] Determined by the chromogen technique except in the case of the hay lot.
* Significant at 5% level:
(a) TDN determined by chromogen technique: Significant when compared to the two pasture lots.
(b) TDN calculated from gains: Significant when compared to all other lots.
(c) Daily gains: Significant compared to all other lots.
(d) Gain per 100 lb. TDN: Significant compared to all other lots.
** Significance at the 1% level:
(a) TDN calculated from gains in weight: Highly significant compared to all other lots.
(b) Daily TDN consumption: All differences are highly significant.
(c) Gain per 100 lb. TDN: Highly significant compared to all other lots.

four groups of steers was calculated by the method shown in table 5. By comparing the TDN theoretically required to produce the gain attained with that actually consumed one can obtain some knowledge of how efficiently the TDN consumed was utilized for production of gain. As a further test the gain produced per 100 lb. of TDN consumed has been calculated. These data are shown in table 6. It appears from this information that the TDN consumed by the steers on pasture was utilized more efficiently than that consumed from soilage or hay for the production of gain in weight. Note that to account for a gain of 1.73 lb. per day the forage consumed by the steers on rotation grazing would have to contain 78.9% TDN if the TDN were utilized as expected. This forage actually contained, however, only 57.8%. The difference between the two values for the soilage was much smaller. These comparisons indicate that the productive value of the TDN in the forage from the pastures was higher than that from either the soilage or hay with hay being the lowest. The amount of gain produced per 100 lb. of TDN consumed also indicate the same thing. This leads one to conclude that the TDN content of the pasture had a higher net energy content than the TDN of the soilage or hay. It appears, therefore, that selective grazing may result in the selection of a diet which may be more productive than that which might be clipped while not differing markedly in dry matter digestibility or TDN. This is not out of line with the well known fact that because of the heat increment the productive value of the TDN in feeds high in fiber is, in general, lower than that of feeds low in fiber.

Summary

Studies are reported in which additional support is given the chromogen technique as a method of estimating the dry matter and TDN intake of grazing animals.

A comparison between the chromogen technique and a pre- and post-grazing clipping method indicated that the clipping method greatly overestimated the dry matter and TDN intake of steers grazing alfalfa.

Steers grazing alfalfa made equal gains to those fed alfalfa soilage while consuming 30% less dry matter.

Data are presented indicating that the net energy of the TDN in forage selected by grazing steers may be greater than that of the TDN in harvested fresh forage or hay made from the same crop.

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THE USE OF THE ESOPHAGEAL FISTULA FOR THE DETERMINATION OF CONSUMPTION AND DIGESTIBILITY OF PASTURE FORAGE BY SHEEP [1, 2]

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A METHOD of obtaining representative samples of forage actually eaten by grazing animals has long been a problem. The many methods previously proposed are time consuming and tedious. The use of the esophageal fistula in grazing animals offers a new approach to this problem (Torell, 1954). This paper reports results obtained in testing this technique with these fistulated sheep.

Once a representative sample of forage is obtained, several techniques are available for the determination of consumption and digestibility. Reid *et al.* (1950) have proposed the use of chromogens in the feces. Cook and Harris (1951) had difficulty in using this technique under range conditions. The lignin ratio method proposed by Forbes and Garrigus (1948) appears to be more applicable to all types of forage. Variation in the reported digestibility of lignin introduces some doubt in the accuracy obtained but most results indicate that lignin is only 0 to 5% digestible. Chromic oxide as an indicator substance has been used successfully in mixed rations but its effective use on pasture is limited because of the difficulty encountered in getting it uniformly mixed with the ingested forage.

Experimental and Results

Effect of Collection on the Sample

A study was conducted to test this technique on any change which might take place in forage while in the mouth before dropping out of the fistula. Chopped alfalfa hay was thoroughly mixed and divided into four lots by the quartering method. One lot was taken for chemical

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analyses and the other three lots were fed to a fistulated wether. The three samples collected from the fistulated wether were weighed and analyzed for comparison with the control sample. Results are shown in table 1.

Examination of the analyses indicate that there was little change in the chemical composition of the material during the collection procedure. The ash content of the collected material appears to be somewhat higher than for the control sample. It is theoretically possible to explain this

TABLE 1. COMPARISON OF COMPOSITION OF ALFALFA HAY BEFORE AND AFTER PASSING THROUGH THE MOUTH AND AN ESOPHAGEAL FISTULA

	Dry matter fed	Wet collection	Dry matter collected	Dry matter composition					
				Ash	Protein	Ether extract	Crude fiber	Nitrogen free extract	Lignin
	gm.	gm.	gm.	%	%	%	%	%	%
Control				12.0	27.8	1.3	22.4	36.5	6.8
Fistula									
Collection I	151.7	573	148	12.3	27.4	1.3	22.2	36.8	6.4
Collection II	167.3	804	165	12.9	27.5	1.2	22.2	36.2	6.4
Collection III	145.2	578	148	12.8	27.4	1.2	22.5	36.1	6.3

on the basis of the mineral content of the saliva. The saliva excretion was estimated by the increase in weight of the material as fed and as collected. This increase is shown in table 1. If the saliva is assumed to contain 0.5% mineral, this amount of mineral would increase the ash content of Collection I by 1.4%, Collection II by 1.9%, and Collection III by 1.4%. The ash results would indicate that the effect is somewhat less than estimated by this method. The slightly lower lignin content of the collections compared to the control sample, while within the experimental error of the analyses, may also reflect some selection of the portion of the sample eaten by the wether as there was a small weigh-back in every case. This would not be a factor in pasture collections as only the part actually eaten is of interest. McDougall (1948) reported sheep saliva contained 0.7 to 0.9% ash.

Consumption and Digestion Trials

With the above test indicating that there was little change in forage during the esophageal fistula collection, trials were conducted on three types of irrigated pastures. Two esophageal fistulated wethers were used to make collections of the pasture forage. Since collections and leakage

at the fistula decrease the amount of feed actually taken into the digestive tract by the fistulated animals, it was thought desirable to take fecal collections from three normal non-fistulated wethers which had been fitted with fecal collection bags. This technique was therefore based on the assumption that all five sheep ate the same quality of forage from the pastures. The three wethers used for fecal collections weighed 84, 89, and 127 lb. at the conclusion of the trials.

TABLE 2. CHEMICAL COMPOSITION ON ESOPHAGEAL FISTULA COLLECTIONS AND HAND CLIPPED FORAGE FROM THREE KINDS OF PASTURE

			% Dry basis			
Pasture	Sheep no.	Date	Ash	Protein	Lignin	Ether extract
Sudan	1	August 12	14.6	15.5	8.4	1.59
Sudan	3	August 12	13.4	16.1	8.4	1.62
Sudan	1	August 14	14.0	14.5	8.8	1.75
Sudan	3	August 14	12.0	13.6	9.3	1.52
Sudan	1	August 17	16.6	16.8	9.7	1.74
Sudan	3	August 17	11.6	14.7	8.5	1.30
Sudan	Average 6 collections		13.7±1.8	15.2±1.1	8.85±.5	1.59±.2
Sudan	Hand clipped August 17		12.2	8.1	6.5	1.61
Trefoil	3	August 27	13.0	25.8	6.9	2.60
Trefoil	3	August 29	11.9	28.2	7.1	2.88
Trefoil	3	August 30	11.9	26.8	5.9	2.37
Trefoil	3	August 30	11.2	27.2	6.4	2.47
Trefoil	Average 4 collections		12.0±0.7	27.0±1.0	6.6±.5	2.58±.2
Alfalfa	1	September 13	10.8	27.3	6.6	1.63
Alfalfa	3	September 13	14.8	24.5	5.6	1.89
Alfalfa	1	September 16	10.5	22.2	7.4	1.86
Alfalfa	Average 3 collections		12.0±2.4	24.7±2.9	6.5±.9	1.79±.1
Alfalfa	Hand clipped September 18		8.8	21.6	5.5	2.13

The five wethers were placed in each pasture one week before the actual trials were conducted in order that they might become accustomed to the forage and to allow time for previous feed to clear the digestive tract of the wethers used for fecal collections.

Fistula collections were attempted at the beginning, mid point, and near the end of each test period. Some difficulty was encountered in some of the collections so results are reported only where forage samples adequate for analyses and free of rumen contents were obtained. (An occasional collection was ruined by regurgitation.)

For comparative purposes, square-foot plots randomly located in the sudan and alfalfa pastures were hand clipped. The analyses of the esophageal fistula collections and the hand-clipped samples are shown in table 2.

The sudan pasture tested was almost pure Sudan grass. The pasture had been previously grazed and clipped. Most of the plants were about six to eight inches high and in the vegetative stage during the test. A small amount of Sudan on the irrigation checks and near the fence was more mature with seed heads developing.

The trefoil was a 91% pure stand of narrowleaf birdsfoot trefoil (*Lotus tenuis*) with yellow star thistles and peaweed as impurities. When grazed it was about eight inches high with some blooms and some seed heads developing.

The alfalfa field was a pure stand of alfalfa with a small amount of dry weedy material around the fences. The stage of maturity was somewhat variable due to some dry, sandy areas in the pasture, and varied from no bloom in some areas to 100% bloom in others.

The feces were collected from the three intact wethers twice daily, dried, weighed, and an aliquot taken for analyses for ash, lignin, and nitrogen. Using the lignin-ratio method of Forbes and Garrigus (1948) and the total digestible nutrients method of Lofgreen (1953), daily dry matter consumption, total digestible nutrients and percent digestible protein were calculated. (table 3).

Discussion

The use of fistulated wethers to collect representative samples of pasture or range forage and similar intact wethers to collect feces from such forage gives promise of a useful technique for measuring consumption and digestibility of such forage. Further refinements of the technique are needed for more precise results. The forage collections should precede the fecal collections by an interval equal to the time it takes the forage under study to pass through the digestive tract. This could be obtained by giving a marker to the intact sheep when turned into a study area.

More data are needed to determine the variability between samples collected by the same fistulated sheep on the same pasture. Data are also needed on the variability of samples collected by different fistulated sheep on the same pasture. Studies currently underway on this subject will be published in a later paper.

TABLE 3. RESULTS CALCULATED FROM FECAL COLLECTIONS

Pasture	Sheep no.	Daily fecal wt. dry matter	Daily feed intake dry matter	T.D.N dry-basis	Protein digestibility	Digestible protein
		gm.	gm.	%	%	%
Sudan	13	412	828.7	48.0	56.8	8.6
Sudan	32	366	653.4	45.3	44.5	6.8
Sudan	65	345	643.2	46.7	44.7	6.8
Trefoil	13	381	1166.1	63.4	78.7	21.2
Trefoil	32	309	997.3	64.7	76.3	20.6
Trefoil	65	350	1145.5	64.9	78.1	21.1
Alfalfa	13	439	1350.8	62.4	76.5	18.9
Alfalfa	32	411	1138.2	59.7	71.7	17.7
Alfalfa	65	339	964.8	59.8	75.2	18.6

The most difficult task in connection with this procedure was keeping the fistulated sheep in good health and in condition to make the collections. Experience to date indicates that the fistulated sheep require careful daily attention. The fistula may be kept closed with double layers of plastic—one layer in the esophagus and a second on the outside of the skin—and the two laced together with heavy nylon fishline. Two of the wethers used for these studies (No. 1 and 3) were operated on in June, 1954, and were in thrifty condition 20 months later.

Collection periods should not exceed 30 minutes or the sample may be lost by regurgitation and contamination with rumen contents. Larger collections can usually be obtained by keeping the fistulated wethers off feed the night preceding the collection period.

TABLE 4. COMPARISON OF TEST RESULTS WITH MORRISON'S REQUIREMENTS FOR "GROWING EWE LAMBS AND YEARLINGS" IN THREE WEIGHT CLASSIFICATIONS

	80-lb. lambs	90-lb. lambs	120-lb. lambs
	lb.	lb.	lb.
Dry matter			
Required [a]	2.2–2.7	2.3–2.8	2.6–3.1
Sudan test	1.4	1.4	1.8
Trefoil test	2.5	2.2	2.6
Alfalfa test	2.1	2.5	3.0
Total digestible nutrients			
Required [a]	1.4–1.7	1.5–1.8	1.8–2.1
Sudan test	.7	.6	.9
Trefoil test	1.6	1.4	1.6
Alfalfa test	1.3	1.5	1.9

[a] Morrison's table III.

A comparison of the results obtained from this test with Morrison's (1948) requirements for lambs is shown in table 4. The low intake on the Sudan pasture may in part be due to the fact that the intact lambs were not accustomed to the fecal collection bags. The values obtained on the trefoil and the alfalfa compare rather favorably with Morrison's tables. Further trials are needed to determine the gain of lambs on pasture and determine the actual intake of dry matter and T.D.N. of such lambs on the pasture.

Summary

A test conducted to study the change in chemical composition of forage during the process of passing through the mouth and out an esophageal fistula indicated that there was little difference between the sample fed and that collected from the fistula.

A technique is described in which esophageal fistulated wethers were used to collect samples of Sudan grass, trefoil, and alfalfa pasture as consumed by grazing sheep and normal wethers equipped with fecal collection harnesses were used to collect feces. Assuming that all sheep are eating the same quality forage and using the lignin-ratio procedure, dry matter consumption, total digestible nutrients, and digestible protein of the pasture forage were calculated.

Improvements and possible use of this technique are discussed.

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DIGESTIBILITY OF VARIOUS RATIONS BY STEERS AS INFLUENCED BY THE LENGTH OF PRELIMINARY FEEDING PERIOD[1]

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IT has been well established that the composition of a ration has a marked influence on the microflora of the rumen. Therefore, it seems reasonable to assume that in a digestion trial a sufficient length of time must elapse to allow the microflora to adjust to the new ration before collection of the excreta is begun. This is especially true for experiments employing a change-over design in which the same animal is fed a series of different rations.

In the early digestion trials the length of preliminary feeding periods was dictated largely by how long it took to get the animals on a constant feed intake, and by observations of the length of time required for feed to pass through the digestive tract. Kellner (1898) stated that a preliminary period of at least five days should be allowed for ruminants so that all residues of previously ingested feed would be voided. Forbes and Grindley (1923) in their review, note the lack of experimental evidence as to just how long the change-over periods of digestion trials should be.

Hall and Woolfolk (1952) compared various lengths of preliminary and collection periods in digestion trials with lambs fed chopped alfalfa hay. The lambs were taken off pasture, fed hay for one week and then put on trial. No differences in digestibility were noted when the preliminary period was three days or when it was as long as ten days.

The influence of length of preliminary feeding on digestibility by sheep has recently been reported by Lloyd *et al.* (1956). In this experiment the sheep were removed from pasture and placed on a ration consisting solely of field-cured hay. Fecal samples were collected and analyzed daily for proximate composition for 70 days. Following this the animals were changed to a ration of 65% hay and 35% grain (60% whole oats and 40% wheat bran) and the same procedure repeated. Running, 10 day averages of the digestion coefficients were calculated and plotted on a graph so that comparisons of preliminary periods varying from 0 to 60 days were possible. They found rhythmic fluctuations in di-

[1] These studies were supported in part by a grant from Publicker Industries, Inc., Philadelphia, Pa., through the cooperation of Biren Bass.
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gestibility which led them to suggest that a maximum and constant digestibility was not biologically normal. It was concluded that there was no advantage to increasing length of preliminary period beyond 10 days.

Tillman *et al.* (1954) and Chappel *et al.* (1955) noted in preliminary experiments that there appeared to be an effect of time in attainment of maximum response from alfalfa ash supplements. This observation was investigated further in two trials published by these same workers. In one trial a corn cob basal ration was fed with an 8-day preliminary period followed by eight successive 3-day collection periods. The second trial used a prairie hay basal ration with 7-day preliminary periods and six consecutive 3-day preliminary periods. In both cases they did not obtain consistent changes in digestibility with advancing time.

In investigations at Ohio (Burroughs *et al.*, 1950) a water extract of alfalfa was added to a basal ration consisting of corn cobs, corn starch, dried skim mlik, bone meal and salt. The average digestibility of the ration increased for each of three consecutive 10-day collection periods. When the supplement was removed from the ration the digestibility remained high (48.4%) for the first 10-day collection, but dropped to 34.4% during the second 10-day period.

Reports have appeared in the literature showing that changes in the ration result in a change in the rumen microflora. However, these reports do not go on to show that the change in microflora results in a measurable change in digestibility. Of the literature reviewed only the report of Burroughs *et al.* (1950) indicated that there was a change in digestibility associated with time after a change in the ration.

As the search of the literature failed to reveal clear evidence as to the optimum length of preliminary feeding period that should be employed in a digestion trial, two series of trials were conducted to investigate the influence of different lengths of preliminary feeding varying from 7 to 44 days on the digestibility of rations of markedly different composition.

Experimental

Trial I

The animals used were four dairy type steers weighing approximately 450 lb., which had been fitted with rumen fistula two months prior to the beginning of the experiment. Immediately preceding the first preliminary period the animals were fed an all hay ration from the same

lot of hay as was used throughout the entire experimental period. The hay was second cutting U. S. No. 1 alfalfa light grass mixed. The concentrate mixture was composed of ground corn, 70%; corn distillers dried grains with solubles, 28%; iodized salt, 1%; and dicalcium phosphate, 1%.

Each animal was assigned at random to one of four rations arranged in a 4 × 4 latin square design. The rations were designated as A, B, C, and D, where ration A consisted of 100% hay, ration B, 75% hay and

TABLE 1. RATIONS FOR A 500 LB. STEER, TRIAL II

Constituents	Rations, lb.					
	1	2	3	4	5	6
Timothy hay	4.0	4.0	8.0	8.0	8.0	8.0
Alfalfa hay	4.0	4.0				
Corn meal	2.0	1.88	2.0	1.13	2.0	1.25
Soybean oil meal		0.12[a]		0.87[a]		0.75
Urea			0.1105[a]		0.0954	
Distillers dried molasses solubles	0.3				0.3	0.3
Dicalcium phosphate	0.1	0.1	0.1	0.1	0.1	0.1
Estimated digestible protein equivalent	0.72	0.72	0.69	0.70	0.69	0.70
Calculated crude fiber (%)	26.4	27.0	29.7	30.3	29.0	29.5

[a] Adjustments in amounts of these high nitrogen feeds were to compensate for the protein equivalent (13%) of the DDMS supplement, thus, maintaining equal protein equivalent on comparable rations.

25% grain, ration C, 50% hay and 50% grain, and Ration D, 35% hay and 65% grain on a weight basis. These rations were fed so as to supply approximately 75% of Morrison's (1948) minimum requirements of total digestible nutrients. Protein was adequate for all of the rations.

Each experimental period consisted of 49 days. Five-day collection periods were conducted the last five days of each third, fifth and seventh week. Thus, each collection period was preceded by a preliminary feeding period of 16, 30 and 44 days. Standard procedures were followed in determining the proximate composition of the feeds and excreta according to the Association of Official Agricultural Chemists (1955).

Trial II

Six yearling, dairy type steers weighing approximately 500 lb. were assigned at random, according to a 6 × 6 latin square design, to one of

six rations which varied less markedly in composition than those in trial I. Late-cut timothy hay of medium to low quality, and corn meal were the basic constituents for all the rations. The rations differed as to the source of additional protein which was provided by alfalfa hay, soybean oil meal, or urea. Each of the three rations was fed with and without the addition of Distillers Dried Molasses Solubles (DDMS) [3] at the rate of 3% of the total ration. Iodized salt blocks were provided.

Table 1 shows how these constituents were combined in the various rations as calculated for a 500-lb. steer.

TABLE 2. SOURCES OF VARIATION USED IN THE ANALYSIS

Source	Degrees of freedom		Mean square, Trial I	
	Trial I	Trial II	Crude fiber	Dry matter
Periods	3	5	513.47	181.99
Steers	3	5	429.03	84.70
Rations	3	5	1165.19**	407.61**
Error (a)	6	20	92.46	4.62
Collections	2	1	233.75*	35.57
Collections×periods	6	5	147.79	46.51
Collections×steers	6	5	34.93	14.60
Collections×rations	6	5	24.98	5.54**
Error (b)	12	20	64.96	0.53

* Significant at 5% level.
** Significant at 1% level.

The animals were fed a ratio of 4 lb. of roughage to 1 lb. of grain in all rations, and these were fed at such a level as to provide between 80 and 90% of Morrison's (1948) minimum requirements for digestible protein and total digestible nutrients for growing dairy animals. Since there was considerable variation in body weight (a maximum of 240 lb. between steers from the beginning to the end of the experiment), it was necessary to adjust the ratio of protein supplement to corn meal in order to keep within the stated range for both total digestible nutrients and digestible protein for all animals (Nicholson, 1956). In no case was the adjustment so extensive as to be likely to cause a change in digestibility of the ration.

A 5-day collection period was conducted after the animals had been on preliminary feeding for 7 days, and again when the animals had been on preliminary feeding for 21 days.

Samples of the feeds fed were saved at each feeding, commencing one day before the beginning of each collection period and ending one

[3] Fermentation residue from the production of ethyl alcohol from molasses.

day before the collection ended. The daily samples were composited and analyzed separately for each collection period. The same sampling procedure was used in both trials.

Each trial was statistically analyzed as a split-plot design in which the collections within each experimental period were considered sub-plots (three sub-plots in the first trial and two in the second trial). The "collection × steers" mean square was used to test "collections" (length of preliminary period) using Duncan's multiple range test as described by Federer (1955).

TABLE 3. DIGESTION COEFFICIENTS FOR 16, 30 AND 44 DAYS PRELIMINARY FEEDING PERIODS, TRIAL I

	Days preliminary period[a]		
	16	30	44
Dry matter	63.2	61.8	60.3
Crude protein	70.9	70.7	69.9
Ether extract	58.0	57.8	47.6
Crude fiber	24.9*	17.9	18.7
N.F.E.	76.9	76.4	75.9

[a] Average of 4 steers.
* Significantly greater than the other two preliminary periods ($P<0.05$).

In table 2 is a list of the sources of variation for both trials and the mean squares for crude fiber and dry matter digestion coefficients in trial I.

Results and Discussion

Trial I

The coefficients of apparent digestibility of the rations are presented in table 3. The digestibility of the different rations used in the first trial have been previously reported (Haynes *et al.*, 1955). It was suggested that the low digestibility of the crude fiber obtained may have been due to the use of fistulated steers or to the low roughage content of some of the rations.

Mead and Goss (1935) reported a low digestion coefficient for crude fiber of an all-concentrate ration by dairy heifers. Although statistically significant ($P<.05$) only for crude fiber, there was a decrease in average digestibility with increasing time for all nutrients. In each case this decrease was least (or absent) for the 75% hay, 25% grain ration. This difference in response by the one ration resulted in a significant ($P<.01$)

TABLE 4. MEAN DRY MATTER DIGESTION COEFFICIENTS FOR 16, 30 AND 44 DAYS PRELIMINARY FEEDING PERIODS, TRIAL I

Ration	Days preliminary period[a]		
	16	30	44
100% hay	56.6	55.2	52.5
75% hay—25% grain	59.0	59.7	59.0
50% hay—50% grain	68.9	65.6	65.0
35% hay—65% grain	68.6	66.8	64.5

[a] Average of 4 steers.

interaction between collections (length of preliminary period) and rations for dry matter digestibility. Mean dry matter digestion coefficients are shown in table 4.

Considering the excellent quality of the alfalfa hay used it is difficult to explain why there was a decrease in digestibility on the all hay ration as the length of preliminary period increased. It may be that the grain supplied something which resulted in a more active rumen microflora than was possible when hay alone was fed.

These results indicate that when changes are made in the ration which involve such a radical shift in the hay to grain ratio as used in this trial, a 16-day preliminary period is not long enough for reliable results. The difference between the 30- and 44-day preliminary periods was not significant. Therefore, the optimum length of preliminary feeding period appears to be somewhere between 16 and 30 days for digestion trials involving ration changes as great as used in these studies.

Trail II

The average digestion coefficients for trial II are presented in table 5. There was a significantly greater ($P<.05$) digestibility of crude fiber after three weeks than after one week preliminary feeding period. On

TABLE 5. MEAN DIGESTION COEFFICIENTS FOR 7- AND 21-DAY PRELIMINARY FEEDING PERIODS, TRIAL II

	Days preliminary period	
	7	21
Dry matter	62.6	62.6
Crude protein	65.6	65.2
Ether extract	54.4	52.8
Crude fiber	54.6	55.9
N.F.E.	69.2	68.4

the other hand the nitrogen-free extract fraction was less efficiently ($P<.05$) digested after three weeks of preliminary feeding. The effect of these two changes was to offset each other so that there was no change in the digestibility of total dry matter. The changes in digestibility of protein and ether extract were slight and not statistically significant.

There were no significant "collection $\times$ ration" interaction in trial II, indicating that all rations responded similarly toward the two lengths of preliminary feeding periods.

From the data presented it seems that a shorter period of time is required for the animal to adjust to changes of this type than to more drastic changes such as those in trial I. In most digestion or balance trials the investigator is interested in the effect of change in feeds or supplements when the hay to grain ratio remains fairly constant. From the data reported here it would seem that a preliminary feeding period of 7-days is adequate for such trials.

In both trials, due to the relatively low level of feeding, no difficulty was encountered with feed consumption. For this reason, length of the preliminary feeding period is the same as days on constant feed intake.

Summary

Two series of digestion trials were conducted with steers in an effort to establish an optimum length for the preliminary feeding period.

Preliminary periods of 16, 30 and 44 days were used in one trial with rations that varied widely in hay to grain ratios. Periods of 7 and 21 days were used in the second trial in which the rations were held constant in hay to grain ratios at 4:1, but differed as to the protein supplement.

It was concluded that longer preliminary feeding periods are needed when the hay to grain ratio fluctuates widely. The optimum period for such trials lies between 16 and 30 days. For rations in which the basic components and the hay to grain ratio are constant, but protein supplement varies, a preliminary feeding period of 7 days appears adequate.

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FACTORS INFLUENCING *IN VITRO* RUMEN CELLULOSE DIGESTION

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CELLULOSE digestion by rumen microorganisms has long been considered the most important energy-producing mechanism for ruminants. Many investigators have studied *in vitro* cellulose digestion using several different technics. Hungate (1947), Sijpesteijn (1951), Bryant and Burkey (1953) used pure cultures for some studies on cellulose digestion. Burroughs *et al.* (1950a) used diluted rumen fluid as the inoculum. Cheng *et al.* (1955) modified this technic by centrifuging and washing the rumen cells. Bentley *et al.* (1954a) employed centrifuged, unwashed bacterial cells from rumen fluid, while Wasserman *et al.* (1952) and Huhtanen *et al.* (1954a) worked with the whole unaltered rumen fluid. The latter technic is the basis for the following investigations.

Experimental Procedures and Results

The methods used for assaying cellulose digestion were those of Huhtanen *et al.* (1954a). The rumen samples were obtained from sheep with permanent rumen fistulae and filtered through cheesecloth to remove large plant particles. The sheep were maintained on a stock grain ration with timothy hay. All experimental materials were added to the inside sack containing the rumen fluid and to the outside dialyzing fluid to equalize the concentrations.

Bentley *et al.* (1954b), using the centrifuged cell technic, reported that certain volatile fatty acids, especially n-valeric and isovaleric acids were stimulatory for cellulose digestion in the absence of rumen fluid. Our attempts to demonstrate such a stimulation with the whole rumen fluid were uniformly unsuccessful over concentration ranges of 5 to 250 mcg. per ml. of the fatty acids. No inhibition of digestion was noted with either alfalfa meal or Solka Floc #200 (Brown Company, Berlin, New Hampshire). Rumen fluid dialyzed for 4 hours in a refrigerator against 10 volumes of distilled water exhibited no loss of cellulose digesting activity and was not stimulated by these fatty acids.

The effect of the antibiotic, chlortetracycline hydrochloride on cellulose digestion was further investigated. Wasserman *et al.* (1952) showed

TABLE 1. THE EFFECT OF CHLORTETRACYCLINE ON CELLULOSE DIGESTION AND ITS PARTIAL REVERSAL WITH FISH SOLUBLES

Chlortetracycline	Additions	Digested
mcg./ml.		%
20	0	28, 28[c]
20	casein[a]	24, 30
20	fish solubles[b]	38, 40
10	0	39, 28
10	casein	36, 38
10	fish solubles	42, 49
5	0	46, 43
5	casein	45, 36
5	fish solubles	46, 42

The digestion of the control was about 50%.

[a] Casein at 0.25%.
[b] Fish solubles at 0.50%.
[c] Results from duplicate samples.

that antibiotics interfered with *in vitro* cellulose digestion. Table 1 shows that high concentrations of chlortetracycline will inhibit cellulose digestion. Partial reversal of this inhibition may be accomplished by adding 0.5% fish solubles but not by the addition of casein. A second experiment was conducted in which 20 mg. of chlortetracycline hydrochloride was fed to a fistulated sheep for a period of 30 days. The ability of the bacteria to digest the cellulose of alfalfa leaf meal was determined. The

TABLE 2. THE EFFECT OF FEEDING CLORTETRACYCLINE ON THE DIGESTION OF ALFALFA LEAF MEAL

Days on feed[a]	Cellulose digested	Average
	%	
0	[b]	48
3	54, 46	50
5	42, 56	49
9	58, 56	57
11	61, 56	58
12	60, 61	60
17	54, 47	50
23	49, 52	51[c]
30	53, 44	48

[a] The sheep (approximate weight 45 kg.) was fed 20 mg. chlortetracycline per day in the grain. The sheep consumed about 1.6 lb. hay and 0.4 lb. grain per day.
[b] Values for control were 50, 41, 43, 49, 50, 53% determined at random intervals before the experiment.
[c] There was no significant difference in digestion.

results are shown in table 2. This form of antibiotic when fed had no correlative inhibitory action on cellulose digestion over the test period. It was noted during the course of this experiment that the gas production by the rumen microorganisms increased greatly after a few days on the antibiotic regime. Often the dialyzing sacks containing the rumen fluid filled with gas in a few hours and would practically disintegrate. No actual digestion of the sack could be detected although it was very greatly weakened. This phenomenon of the sack disintegration has been noted only with antibiotic-fed ruminants or on very prolonged (48 hours) incubation of rumen fluid.

All experimental results involving different sources of cellulose indi-

TABLE 3. EFFECT OF SOLVENT EXTRACTION ON DIGESTION OF ALFALFA LEAF MEAL

Extraction[a]	Cellulose present	Cellulose digested
	mg.	%
None	166	49, 44
Water	188	36, 21
70% Methanol	179	13, 9
95% Methanol	176	39, 50
70% Acetone	166	20, 11
100% Acetone	172	44, 42

[a] Boiling solvent.

cated that the cellulose from alfalfa meal was most rapidly attacked, followed by that from a poorer quality roughage, such as timothy, and lastly, the purified wood cellulose, Solka Floc. Attempts to increase digestion of the Solka Floc by supplementation with known vitamins, alfalfa ash, glucose, yeast extract, or casein were fruitless although it has been noted in experiments with steers that the addition of 50 mg. Difco yeast extract or enzyme hydrolyzed casein (Sheffield's N-Z amine A) to the *in vitro* system increased the digestion of Solka Floc by as much as 100% over the control (Huhtanen and Saunders, 1954b).[1]

Alfalfa meal was extracted with boiling solvents in an attempt to decrease digestibility of the cellulose by removal of postulated cellulolytic factors. Five grams of alfalfa meal were extracted with 300 ml. of the appropriate solvent by heating to boiling for 30 minutes. The residue was filtered and extracted once more. The fiber was then oven dried at 45° C. The results are shown in table 3.

[1] This information was made available through the courtesy of the National Dairy Research Laboratories, Inc., Oakdale, New York.

No decrease in digestion was noted by extraction with absolute acetone or 95% methanol while a slight decrease was caused by the hot water extraction. Extraction with 70% methyl alcohol or 70% acetone, however, resulted in a decrease of nearly one-half in the amount of cellulose digested. The apparent cellulose content of the extracted meal was decreased by the water and methanol treatments probably by the removal of soluble components. Supplementing the extracted residues from the 70% alcohol-treated alfalfa with vitamins, minerals, yeast extract, fish solubles, corn solubles or enzyme hydrolyzed casein did not restore the normal rate of digestion. The dried filtrate of the 70% alcohol extraction also failed to restore digestion.

TABLE 4. EFFECT OF VARYING SUBSTRATE CONCENTRATION ON CELLULOSE DIGESTION

Alfalfa meal per sack	Cellulose digested	Cellulose digested
mg.	mg.	%
50	5	50, 50
100	9	45, 55
200	23	57, 53
400	36	45, 47
600	59	50, 56

Extraction with hexane, petroleum ether, isopropyl ether or isopropyl alcohol had no effect on the rate of digestion.

The extracted alfalfa, having lost its wetability, was incubated with 5 to 100 mcg. of Aerosol OT [2] surface active agent, coumarin, sodium taurocholate or Tween 80. Little or no increase in digestion of cellulose due to the addition of these materials was noted.

Studies on the effect of varying substrate concentration showed that the cellulose of alfalfa meal was attacked only to a certain extent and that the percent digested was constant regardless of the amount of substrate present. This is shown in table 4. Although the amount of cellulose that was digested varied from 5 to 60 mg. the amount digested remained at or near 50%.

Table 5 shows the effect of dilution of the rumen fluid on cellulose digestion. One-fifth dilution of the original fluid had no effect while further dilution resulted in a progressive diminuation of activity.

The effect of time on cellulose digestion showed typical values as follows: at 6 hours—17%, at 12 hours—34%, at 18 hours—40%, and

[2] Reg. U. S. Pat. Off.

TABLE 5. EFFECT OF DILUTION OF RUMEN FLUID ON ALFALFA MEAL CELLULOSE DIGESTION

Rumen fluid	Buffer[a]	Digested
ml.	ml.	%
10	0	42, 50
8	2	46, 45
6	4	48, 44
2	8	45, 35
1	9	35, 30
0.5	9.5	21, 28

[a] Regular synthetic saliva mixture.

at 24 hours—49%. The 24-hour period, being most convenient, was adopted as the regular incubation time.

Table 6 shows the effect of urea and glucose additions on cellulose digestion. Either urea or glucose markedly inhibited the breakdown of the cellulose in timothy but when added together, normal activity was restored. The effect was less marked or absent with alfalfa meal.

Discussion

The failure to show stimulation of cellulose digestion by valeric or isovaleric acids indicated that these fatty acids are normally present in sufficient amounts or that they can be readily formed by rumen microorganisms. The work of Annison (1954) and Annison and Pennington (1954) confirms the presence of these fatty acids in normal rumen fluid. The centrifuged cell technic could thus give misleading information concerning the requirements for cellulose digestion of the normal rumen population within the animal, although possibly yielding excellent fundamental knowledge of the activities of the rumen bacteria on single substrate.

It is possible that deficiencies in these fatty acids could occur under certain conditions; therefore, it would seem important to establish

TABLE 6. EFFECT OF GLUCOSE AND UREA ON CELLULOSE DIGESTION

Additions	% Digested	
	Timothy	Alfalfa
Control	27, 33	49, 41
Urea (0.5%)	0, 0	50, 36
Glucose (0.5%)	0, 0	29, 34
Urea (0.5%), Glucose (0.5%)	27, 22	43, 44

whether these fatty acids are at any time absent from the rumen of animals fed different rations.

The influence of chlortetracycline on pure cultures of rumen microorganisms was shown to be of the same order of magnitude as for a typical test organism, *Bacillus cereus* (Huhtanen and Gall, 1952). However, 10 or 100-fold concentrations are necessary to appreciably inhibit cellulose digestion when normal rumen fluid is used. This is probably a reflection of the tremendously large numbers of bacteria in the rumen as well as the stage of their life cycle. Probably most of the rumen bacteria are in a nonproliferating stage and thus are not susceptible to the action of the antibiotics. The partial reversal of chlortetracycline by fish solubles remains unexplained.

The feeding of an antibiotic to sheep at 20 mg. per day may be calculated to give a maximum antibiotic concentration of nearly 1 mcg. per ml. at any one time assuming a rumen capacity of 20 liters and an equal distribution of the antibiotic. This level had no demonstrable effect on cellulose digestion and may stimulate certain of the rumen bacteria since increased gas production by the rumen microorganisms was observed when the host animal received this amount of antibiotic.

The interesting phenomenon of the digestion of alfalfa meal being limited to a certain portion of the total apparent cellulose may be explained several ways: 1. That the surface area of the particles is the limiting factor in determining the numbers of bacteria which can become attached, or 2. That an accessory factor for cellulose digestion is present in the alfalfa, or 3. That lignification renders a certain portion of the cellulose unavailable.

The first alternative is unlikely since the work of Cheng *et al.* (1955) showed that a purified cellulose is digested in an expected manner, i.e. a higher percentage digestion with smaller amounts of substrate.

Baker and Harriss (1947) discussed the retarding effect of lignin on cellulose digestion, a factor which is unquestionably of great economic significance. If lignification were the sole answer to this phenomenon however, one would expect that the purified cellulose would be attacked at a more rapid rate than the native alfalfa cellulose. This was not the case.

It is tempting to speculate that the second possibility is the most likely, since extraction of alfalfa with a suitable solvent markedly decreases the digestion of the cellulose. In view of the poor digestion of a purified cellulose, it would appear also that the concept of an accessory factor in alfalfa is justified, although supplementation with various

sources of vitamins and growth factors failed to restore activity. The presence of such factors in natural feeds was indicated by Bentley *et al.* (1954a) and Burroughs *et al.* (1950b, 1950c). The factor postulated in this report is probably not a mineral since it was not appreciably removed by hot water extraction. It is not lipid since lipid solvents failed to decrease activity. There is a possibility that the factor is an alcohol soluble protein such as a prolamine. It is possible, also that the solvent treatment causes a denaturation of the proteins of the alfalfa thus making them unavailable to the microorganisms.

The inhibitory effect of high levels of glucose may be explained on the basis of availability of energy sources for the rumen bacteria. If enough glucose is present, the organisms will use it for a carbon source, rather than the less available cellulose. The inhibition of cellulose digestion by urea is more difficult to interpret, but it may be that the bacteria which are able to utilize ammonia as a nitrogen source exhaust the small amounts of glucose which may be stimulatory to cellulose digestion. When both urea and glucose are present, reestablishment of the normal balance is indicated with the possibility that one group of organisms is using glucose and ammonia, and thus leaving the cellulolytic types undisturbed.

There has been no evidence throughout these tests that rumen fluid quickly deteriorates on contact with air or upon dilution. Thus, dialysis for several hours or dilution of rumen fluid to one-fifth normal produces no diminution of activity. The fastidiousness of the rumen bacteria is probably an artifact encountered when working with pure cultures. The ease of cross-inoculation between old and young animals would support this contention.

Summary

A study was made of factors influencing the digestion of cellulose by whole, unaltered rumen fluid.

The addition of n-valeric or isovaleric acids in concentrations of 5 to 250 mcg. per ml. had no effect on cellulose digestion.

Chlortetracycline, when fed to sheep at 20 mg. per day, had no appreciable effect on the ability of the rumen bacteria to digest the cellulose of alfalfa leaf meal.

Studies on varying the amount of alfalfa showed that only about one-half of the cellulose was available to the organisms, regardless of the amount of alfalfa meal present.

Of the three sources of cellulose studied, alfalfa meal was found to be most rapidly attacked; timothy was intermediate and Solka Floc was most resistant.

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FURTHER EXPERIMENTS WITH SODIUM BISULFITE AS A PRESERVATIVE FOR GRASS SILAGE [1]

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SODIUM metabisulfite was first recommended as a preservative for grass silage as a result of experiments conducted at the Pennsylvania Agricultural Experiment Station during 1951 and 1952 (Cowan *et al.*, 1953). More recent reports by Bratzler *et al* (1955, 1955a) have summarized these results and those of further experiments completed in 1954. These tests included comparisons of various methods of silage preservation, with a variety of crops and ensiling conditions, both in small experimental silos, and full size farm silos. The results of these experiments and also analyses reported by Alderman *et al.* (1955b) indicate that bisulfite is effective in reducing fermentation and thus in lessening the changes that take place in treated forage, resulting in silages that more closely resemble the original forages in color, odor, palatability and digestible nutrient content than those prepared by other methods.

In those experiments in which losses of nutrients from the silo were measured, it was found that savings of feed ascribed to the preservative varied from slightly less than enough to pay for the additive in the case of orchard grass in early head, to a resultant "profit" of over $1.00 per ton of forage ensiled in the case of early-cut, legume crops. Cornell workers (Allred *et al.*, 1955) have reported on two experiments in which first cutting legume crops (predominantly red clover) were ensiled with and without bisulfite. Their results indicate that saving of nutrients was not sufficient to pay for the additive, but that color and odor were considerably improved by the addition of bisulfite.

This paper presents the results of two experiments designed to further delineate the conditions under which bisulfite can be used to best advantage.

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Experiment 1—Procedure

In the first experiment, nine experimental silos were filled with first cutting alfalfa harvested at 3 stages of maturity (prebloom, early bloom, and full bloom). Each cutting was ensiled in three ways: (1) bisulfite treated (8 lb. per ton), (2) unwilted, no preservative, (3) wilted, no preservative. The silos used were galvanized steel cylinders,[5] approximately 4 feet in diameter and 8 feet high without bottoms, set on the ground in a well-drained area.

The field chopped forage was placed in the silos by means of a small elevator fitted with a bisulfite applicator. Each load ensiled was carefully weighed, and sampled by grabbing frequent handfuls from the elevator. The material was tramped continuously while filling, covered with a 3–4 in. layer of limestone screenings, and weighted with a 50-gal. steel drum filled with water. Considerable seepage was noted from the silos filled with early-cut, unwilted alfalfa. When settling was finished, the drums were removed and the silos fitted with flat covers of galvanized steel.

The prebloom alfalfa was harvested on May 25 and 26, 1954, and the three treatments applied as follows: Silo 1 unwilted, bisulfite treated (8 lb. per ton); silo 2 unwilted, no preservative; silo 3 wilted, no preservative. About two mower-swaths around the field were required to fill each silo, and the successively numbered silos were filled in sequence so that, as nearly as practicable, all parts of the field were represented in each of the silos.

The early bloom alfalfa (one-tenth bloom) was harvested on June 7 in the same manner from the same field, and ensiled in silos 4, 5, and 6 with the same respective treatments as above. The full bloom alfalfa was harvested on June 22 and ensiled in silos 7, 8 and 9 with the same three treatments.

In addition to the nine silos, silos 10 and 11 were filled on June 7 with forage comparable to the one-tenth bloom alfalfa ensiled in silos 4, 5, and 6.

The silos were opened during the period October 1–January 26, and the silages fed to sheep in digestion trials. When each silo was opened, the limestone screenings were removed, then the top spoilage was removed, weighed and sampled for dry matter determination. The good silage was forked onto a weighed truck, and a sample was taken consisting of a handful from every third forkful thrown out. After weigh-

[5] Constructed by the Clayton and Lambert Mfg. Co. of Cincinnati, Ohio.

ing the total amount removed, the sample was dumped onto a clean concrete floor, mixed thoroughly, and representative 2.500 kg. samples weighed out in duplicate for drying in an electric air oven at 60° C. At the same time samples were taken for Kjeldahl determination of nitrogen. For these determinations twelve 50-gm. samples were digested with 200 ml. each of H_2SO_4—catalyst mixture; then after dilution of the digests to 500 ml., aliquots of 50 ml. were made alkaline and distilled. Also, a 100-gm. sample of the silage was dried using the procedure described by Bratzler *et al.* (1955), to measure volatile dry matter lost on oven drying. Another 100-gm. sample was taken for the determination of pH, volatile fatty acids (calculated as acetic and butyric), and lactic acid according to the procedures described by Alderman *et al.* (1955).

At the same time, individual daily feeds for the digestion trial with sheep were weighed into plastic freezer bags, and kept in frozen storage until fed. The digestion trials were conducted in the usual manner (Swift *et al.*, 1948). A group of four sheep, serving as a unit for evaluating each individual silage, received a constant intake of the silage over a period of 21 days during which time they were housed in individual metabolism cages. Total feces collection was made during the last 10 days of the period. Digestion coefficients of dry matter, energy, and crude protein were determined.

Results of Experiment 1

The composition of the ensiled forages, and of the silage products is shown in table 1. It is apparent that the early cut, (prebloom) unwilted forages (Silos 1 and 2) due to loss of juice, had increased in dry matter content while ensiled. In silo 2 (untreated) part of this moisture loss has been compensated for by water formed as a product of the extensive fermentation, which is further evidenced by the relatively large amounts of volatile fatty acids present, and by the large amount of dry matter lost (table 2). In the case of the one-tenth bloom alfalfa silages, where much less seepage occurred, it is again apparent that the presence of bisulfite has limited the generation of metabolic water due to fermentation; the bisulfite treated silage did not incrase in moisture content, as did the untreated and the wilted silage in this group.

It may be noted that, in the case of the full bloom alfalfa, the moisture content of the unwilted crop (Silos 7 and 8) was within the

TABLE 1. WEIGHT AND COMPOSITION OF FORAGES (AND SILAGES), 1954

Silage treatment	Fresh forages				Silages								
	Fresh weight ensiled	Dry matter	Energy[a]	Crude protein[a]	Top spoilage D.M.	Fresh weight removed[b]	Dry matter	Energy[a]	Crude protein[a]	pH	Lactic acid[a]	Acetic acid[a]	Butyric acid[a]
	lb.	%	cal./gm.	%	lb.	lb.	%	cal./gm.	%		%	%	%
Experiment 1													
Alfalfa, prebloom													
Bisulfite	2935	19.5	4609	22.7	31.0	2210	23.0	4477	20.6	4.3	9.5	1.0	0.3
No preservative	3165	17.3	4568	23.1	35.0	1990	18.3	4805	22.8	5.7	2.4	5.6	7.0
Wilted	2440	29.3	4521	22.1	33.5	2285	23.5	4562	23.2	5.3	2.4	4.8	2.6
Alfalfa, 1/10 bloom													
Bisulfite	2685	22.7	4529	20.6	34.6	2210	22.2	4530	19.9	4.7	11.0	3.5	0.2
No preservative	2545	25.3	4549	20.8	33.0	2080	21.9	4761	22.0	5.3	6.4	4.9	4.5
Wilted	1890	35.5	4555	19.6	44.1	1775	30.3	4591	21.8	5.2	3.2	6.0	2.8
Ground corn cob +bisulfiite	2285	21.4	4555	20.9	88.5	2180	28.3	4432	14.9				
Dried beet pulp +bisulfite	2155	20.6	4451	20.8	52.4	2140	26.6	4284	17.4				
Alfalfa, full bloom													
Bisulfite	2050	28.6	4578	17.5	56.0	1660	26.8	4448	17.5	4.8	6.4	2.7	1.6
No preservative	2085	27.2	4582	18.0	52.5	1680	25.0	4585	17.5	5.5	4.6	4.3	3.9
Wilted	1860	35.7	4594	17.3	195.3	965	34.7	4550	19.7	5.1	5.1	3.6	0.3
Experiment 2													
Alfalfa, 1/4 bloom													
No preservative	13740	22.1	4477	15.6	325	8811	23.7	4519	14.5	4.7	7.2	7.1	0.6
5 lb. bisulfite	14020	22.9	4492	15.8	255	10875	24.6	4488	13.8	5.2	0.6	5.4	0.3
8 lb. bisulfite	11055	20.5	4530	17.8	147	7841	23.6	4396	15.0	4.9	4.0	3.9	0.0
12 lb. bisulfite	22481	19.2	4485	16.4	232	14189	24.2	4438	14.2	4.8	4.7	3.5	0.0
18 lb. bisulfite	17655	19.6	4390	14.7	160	12694	23.3	4369	14.7	5.9	1.4	1.0	0.2

[a] Dry matter basis.
[b] Excluding top spoilage.

range usually recommended for wilted silage, and that the wilted crop (Silo 9) had the same moisture content as that in Silo 6 (wilted, early bloom). However, due to the loss of leaves and increase in the percentage of stems as the crop matured, consolidation of the material in the small silos was poor, resulting in excessive top spoilage and mold, which for the most part accounts for the high percentage of loss from Silo 9 (table 2). It may be observed, from the column in table 1 showing the dry matter discarded as top spoilage, that this is the only instance in which differences in top spoilage contributed significantly to the observed differences in total dry matter lost; in other words, under the conditions of this experiment the differences in loss due to treatment were, with this one exception, essentially a reflection of the influence of the various treatments upon fermentation within the mass of "feedable" silage.

It is apparent from table 2 that the benefit derived from the use of bisulfite was much more significant in the case of the pre-bloom alfalfa than of the more mature cuttings. This was to be expected, as it is well known that such high moisture, high protein crops, when ensiled without preservative, are subject to undesirable types of fermentation which result in high nutrient losses, strong odors, etc. This fact has been partially responsible for the prevalence of the often recommended practice of allowing legume crops to mature to one-tenth to one-half bloom stage before ensiling. However, in view of the excellent retention of nutrients, under the conditions of this experiment, resulting from the addition of bisulfite to the prebloom alfalfa, it would appear that the advantages of ensiling such crops at the early stage may far outweigh the disadvantages. It is obvious that the feeding value of the forage decreases with advancing maturity (see digestion coefficients, table 2). The very high digestion coefficients of the bisulfite treated prebloom alfalfa silage suggest that this silage approaches in quality the type of forage for dairy cows, which might be expected to maintain high milk production with a minimum of supplementation. McCullough (1955) has recently reported results indicating that dairy cows can be maintained in high milk production on pasture alone, provided the pasture is of such quality that its dry matter is at least 70% digestible.

In addition to increased feeding value, other advantages attributed to the practice of ensiling first cutting alfalfa at the prebloom stage are as follows: (1) Forages are more palatable (if well preserved) when harvested early; (2) the second crop benefits from the high soil moisture prevalent early in the season in most areas, thereby increasing the like-

TABLE 2. LOSSES FROM SILOS, DIGESTION COEFFICIENTS OF SILAGES, AND DIGESTIBLE NUTRIENTS RECOVERED PER 100 LB. DRY MATTER ENSILED

Silage treatment	Dry matter			Crude protein			Energy		
	Loss	Digest coeff.	Digest. D.M. per 100 lb. D.M. ensiled	Loss	Digest coeff.	Digest. protein per 100 lb. D.M. ensiled	Loss	Digest coeff.	Digest. energy per 100 lb. D.M. ensiled
Experiment 1	%	%	lb.	%	%	lb.	%	%	Therms
Alfalfa, prebloom									
Bisulfite	12.8	72.7	64.6	19.0	79.8	14.6	13.7	71.2	128.5
No preservative	33.6	66.0	43.8	34.4	79.2	12.0	30.2	66.8	96.7
Wilted	24.7	64.2	48.4	20.8	78.1	13.7	24.0	65.5	102.0
Alfalfa, 1/10 bloom									
Bisulfite	20.8	63.0	50.6	22.4	75.0	12.0	19.6	61.2	101.0
No preservative	29.8	63.0	44.7	25.2	78.5	12.2	25.8	63.9	97.9
Wilted	19.8	63.4	50.9	10.9	75.4	13.2	19.1	62.7	104.7
Ground corn cobs +bisulfite	12.7	68.5	59.8	21.2	74.5	9.0	14.4	66.5	116.8
Dried beet pulp +bisulfite	9.9	70.7	63.7	21.8	72.4	10.1	11.4	68.5	120.0
Alfalfa, full bloom									
Bisulfite	25.5	58.8	44.6	24.5	72.0	9.5	26.4	57.1	87.3
No preservative	26.0	53.4	39.5	20.5	70.1	10.0	26.0	51.8	79.7
Wilted	49.6	57.3	28.9	42.6	72.8	7.2	50.0	54.2	56.4
Experiment 2									
Alfalfa, 1/4 bloom									
No preservative	31.4	60.0	41.2	36.0	62.8	6.3	30.8	57.6	81.0
5 lb. bisulfite	17.6	64.9	54.1	27.1	68.8	7.9	16.7	62.1	104.1
8 lb. bisulfite	20.1	61.8	50.5	30.8	70.8	8.5	20.7	58.0	94.5
12 lb. bisulfite	22.8	59.3	47.0	30.9	66.2	7.3	21.6	56.8	90.6
18 lb. bisulfite	18.1	60.3	51.6	14.1	68.3	8.3	14.8	56.4	95.7

lihood of an additional harvest of high quality feed, as was the case in the field under study in this experiment; and (3) many noxious weeds are prevented from maturing to the seed stage.

It is recognized that part of the apparent increase in nutrient loss associated with advancing maturity, under the conditions of this experiment, was due to lack of height (pressure) to overcome the difficulty of packing due to increased steminess of the crop. This may have placed both the bisulfite and wilting treatments at a disadvantage; wilting because it accentuates the problem of consolidation, and bisulfite because of its sensitivity to oxidation. Part of the initial preserving action of bisulfite arises from this reducing power, which enables it to remove oxygen from the air trapped in the forage at the time of ensiling, thus effectively arresting respiration of the plant tissue which results in reduced heating and nutrient loss. However, in a poorly consolidated mass of silage, ingress of air subsequent to ensiling eventually destroys the bacteriostatic action of the residual bisulfite leaving essentially an untreated silage; in fact it is conceivable that such a silage may be even more subject to spoilage and mold because the presence of the bisulfite in the early stages inhibits production of normal fermentation products, which would otherwise exert preserving action. These considerations serve to emphasize the importance of adequate consolidation of forages in any method of ensiling, and to provide a further argument in favor of ensiling, with preservative, at the early stage of maturity. The use of bisulfite on such early-cut forage insures the production of excellent quality silage, while eliminating the hazards of poor consolidation and the need for critical control of the many unknown and unpredictable factors involved in ensiling methods which depend upon the "art" of controlling dry matter content by means of wilting and chemical composition by selection of suitable crop mixtures, stage of maturity, etc.

Excessive seepage from tower silos filled with high moisture, early cut forage has been an annoying problem for some farmers. In a previous experiment (Bratzler *et al.*, 1955) dried beet pulp had been added, in amounts under 100 lb. per ton, to high moisture clover-alfalfa silages in an attempt to reduce seepage losses. It was found that this amount of beet pulp did not satisfactorily eliminate seepage, and when beet pulp alone was added excessive fermentation loss occurred, which was partially prevented by the use of bisulfite in addition to the beet pulp. It was with this in mind that Silos 10 and 11 were filled with the early bloom alfalfa plus 201 and 183 lb. of ground corn cobs and dried beet

pulp, respectively. Bisulfite was also added to each silo at the rate of 9.2 and 8.4 lb. per ton of forage, respectively. The results shown in table 2 indicate that these additives were effective in reducing losses and in increasing the feeding value of the silage prepared from early bloom alfalfa. It is probable that this effect would have been more pronounced if the same treatment had been applied to the pre-bloom alfalfa.

Experiment 2

In the second experiment, first cutting alfalfa at one-fourth bloom (85% alfalfa, 10% red clover, 5% timothy) was ensiled unwilted in 5 wood stave silos 5 feet in diameter, of which three were 24 feet and two 20 feet high. Filling was started on June 14 and finished on June 17, 1954. The first silo filled received no preservative, and the remaining four received 5, 8, 12, and 18 lb. of bisulfite per ton of green forage, applied by means of an electric powered fertilizer hopper mounted on the blower. Each silo except the last filled (18 lb.) was refilled the day following the first filling. All silos were covered with a 3–4 inch layer of limestone screenings.

It was originally planned to empty these silos in the same manner as were the smaller silos in the first experiment (above), removing, weighing, and sampling all silage the same day, and weighing feeds for the sheep trials from silage representative of the whole silo. This procedure was followed for the first silo opened (no preservative); however it was not convenient to feed all of the surplus silage (about 5–6 tons) at one time. Therefore it was decided to empty the remaining silos over a period of several days each, and to feed the silage not saved for digestion trials to a group of 22 yearling dairy heifers at one of the outlying dairy barns in order to compare palatability of the silages. The heifers were of mixed breeds, and their average weight was estimated by taping to be 668 lb. These heifers had previously been on a ration of medium quality grass silage, poor quality hay, and grain. When feeding of the experimental silages was started, grain feeding was discontinued and the silage was offered ad libitum with twice daily feedings so regulated that some silage was left which was weighed back each morning.

The hay rack was kept filled with the poor quality hay throughout the palatability trials, but the hay intake was not measured. It was felt that having the hay available might accentuate any small difference in

palatability of the silages, as the animals could fill up on hay—in other words they were not forced to "eat silage or starve".

The results of the palatability trial are shown in table 3. These results were somewhat affected by intermittent periods of below-zero weather, during which silage consumption was sharply reduced due to freezing of the silage before it could be eaten. In view of this observation and after a careful examination of the daily consumption data in conjunction with weather records, it appears that a significant reduction of intake of silage occurred only at the highest rate of bisulfite application, 18 lb. However, even at the high level of treatment, consumption of the silage was still considered to be reasonably high and,

TABLE 3. PALATABILITY OF ALFALFA SILAGES TREATED WITH INCREASING LEVELS OF SODIUM BISULFITE

Bisulfite treatment	No. heifers (Av. wt. 668 lb.)	No. days fed	Avergae daily consumption for group
			lb.
5 lb. per ton	22	7	1112
8 lb. per ton	22	4	1022
12 lb per ton	22	6	951
18 lb. per ton	22	9	835

as stated above, the availability of the hay probably contributed considerably to the lowered intake of silage.

During the palatability trial, a 2 kg. sample of each day's feeding was dried in the oven at 60° C., and individual feeds for the digestion trial with sheep were weighed and stored in the freezer. Determinations of dry matter, energy, crude protein, volatile acids, lactic acid, pH, and total volatile dry matter were run on the silage used in the digestion trial. The values for crude protein and energy thus determined, calculated to a dry matter basis and corrected for loss of dry matter on oven drying, were applied to the oven-dry matter values determined on the daily samples, for computing total amounts of these nutrients removed from the silo.

The composition of the forages and silages is shown at the bottom of table 1. The forage ensiled in these silos was not as uniform as to purity of stand as might have been desired, which probably accounts in part for the variability exhibited in the data shown in table 2. How-

ever, it is apparent from the data on losses of nutrients and digestibility that all of the treated silages were superior to the untreated one, with no significant improvement noted above the 5 lb. per ton level.

Summary

Results of Experiment 1 were as follows: Prebloom alfalfa, ensiled wilted or unwilted without preservative, produced poor quality silage with large losses of digestible nutrients. The same crop ensiled unwilted with 8 lb. sodium metabisulfite per ton produced silage of excellent color, odor and feeding value, with greatly increased retention of digestible nutrients.

One-tenth bloom alfalfa was equally well preserved, from the standpoint of nutrient loss, when ensiled wilted or treated with metabisulfite. The bisulfite treated silage, however, was superior in color and odor, and analysis indicated a more desirable type of fermentation. The untreated, unwilted silage made from this crop was inferior with respect to both quality and nutrient losses. Addition of both bisulfite and either dried beet pulp or ground corn cobs to this early bloom alfalfa reduced nutrient losses from the silo, and increased the feeding value of the silage.

Full-bloom alfalfa was considerably lower in feeding value than the two earlier cuttings, and when ensiled unwilted showed little benefit from the use of bisulfite over no preservative. Top spoilage was excessive in the wilted silage made from this crop.

The results of Experiment 2 were as follows:

First cutting alfalfa ensiled in five 5′ × 20′ wood stave silos was treated with 0, 5, 8, 12, and 18 lb. of sodium metabisulfite per ton of fresh forage. All treated silages were superior to the untreated silage with respect to color, odor, and retention of digestible nutrients; however no improvement was noted as the rate of application was increased above 5 lb. per ton, and palatability was impaired slightly at the 18 lb. per ton level.

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PARASITISM IN BEEF YEARLINGS AS RELATED TO FORAGE AVAILABILITY AND LEVELS OF PROTEIN FEEDING

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Georgia Agricultural Experiment Station,[2] Experiment

DURING 4 years of winter grazing experiments conducted on the Piedmont Cooperative Land Use Area near Eatonton, Georgia, (Vegors *et al.*, 1955) grade Hereford yearlings were fed in drylot to compare pasture and drylot performance. There was a small amount of volunteer forage in the drylot. In some years the calves fed in drylot had about as many roundworm parasites as calves on temporary winter pasture. In one year an unexpectedly high level of parasitism was found, the drylot ration that year being low in protein.

Taylor (1934, 1943) demonstrated that lambs receiving a full ration of hay and concentrates had fewer worms at autopsy than lambs fed on hay only. Lucker and Neumayer (1947) found that sheep on a poor diet, generally deficient in protein, had heavier hookworm infections than control animals on a good diet. Weir *et al.* (1948) found that a high level of protein appeared to help sheep withstand an infection of *Haemonchus contortus*, however, the effect of protein on susceptibility to infection with the parasite was not clearly demonstrated.

To determine the factors which may affect internal parasitism of beef yearlings as related to forage availability and level of protein feeding, the following experiments were conducted at the Georgia Experiment Station in 1952 and 1953.

Experimental

The different lots used in these experiments were : (1) A drylot, no grass growth allowed; (2) A semi-drylot, a limited amount of grass (Abruzzi rye) available; and (3) A winter pasture lot composed mostly of Abruzzi rye with ryegrass and crimson clover. All lots were divided in half by fences. Each half of the drylot was about one-tenth acre in size; each half of the semi-drylot was one-fourth to one-half acre, and each half of the pasture lot was 4.5 acres. Two levels of protein, the higher level being 33% greater than the lower level but equated for TDN (total digestible nutrients), were fed to steers in each of the three types of lots.

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In 1952 the tests in drylot and semi-drylot were started on January 2. Due to cold weather the starting of pasture-lot tests was delayed until January 30. Because the semi-drylot grass was sparse and seemed likely to be trampled before an effective level of parasite contamination could become established, a fence was placed across each of its one-fourth acre halves. The calves were then confined to the upper one-third of each half for most of the day and were allowed to graze the lower two-thirds for an hour or two during the day. The grazing time was increased to all night by March 17, and finally free access was allowed on the small amount of grazing from April 14 to the end of the experiment on May 21.

In 1953 the area of each half of the semi-drylot was increased to about half an acre to provide continuous grazing of the small amount of forage from the beginning of the test on December 17, 1952 to the end of the experiment on May 6, 1953. Pasture growth was such that all tests were started at the same time that year.

The animals used in both years were grade Herefords which were about 10 months old at the start of the test in 1952 and about 11 months old when the tests began in 1953. Six groups of six animals each and six groups of five each were used in 1952 and 1953, respectively. Allocations of calves to each of the groups were made on the basis of age, parasite load as indicated by egg counts, weight and feeder grade.

The rations that were fed consisted of sorghum silage, lespedeza or soybean hay, ground corn, soybean or cottonseed meal, and minerals. The cattle on pasture received grain and protein concentrate but no hay or silage. In the first year the animals in the drylot and semi-drylot were fed 9.3 lb. TDN per head daily with 1.37 and 0.94 lb. of digestible protein (DP) per head for the high and low protein groups, respectively. The pastured animals during this same period were fed 2.9 lb. TDN as dry feed per head daily, in addition to the forage they consumed, with 0.58 and 0.39 lb. of DP for the high and low protein groups, respectively. In the second year the groups in drylot and semi-drylot were fed 10.6 lb. TDN per head, the high and low protein groups receiving respectively 1.63 and 1.11 lb. DP daily; the pasture animals were fed 5.1 lb. TDN per head as dry feed supplement on pasture, the high and low protein groups receiving respectively 0.92 and 0.63 lb. DP daily. The ration was calculated to supply about a 33% difference in DP between the high and low protein groups and an equal amount of TDN with each change in feed as the cattle increased their feed intake during the test.

Forage intake and its digestibility by the pasture groups was determined three times during the second year by the chromogen-chromic oxide method. From these determinations it was found that a great excess of digestible protein was consumed and for this reason the planned 33% difference in DP level did not exist between these two

TABLE 1. PARASITISM IN BEEF YEARLINGS AS RELATED TO AMOUNT OF PASTURE HERBAGE AVAILABLE

Items	Drylot	Semi-drylot	Pasture
No. cattle on test	22	22	22
Av. initial weight (lb.)	406.8	408.5	406.2
Av. final weight (lb.)	640.5	672.1	702.5
Av. daily gain (lb.)	1.70	1.91	2.31**
Av. of egg counts[a]	616	497	481
No. cattle exam. postmortem	8	8	8
Av. total no. adult worms	10767	8543	5738
Av. total no. larvae	25*	369	1926
Av. total worm burden	10792	8912	7664
Av. total no. adult intestinal worms[b]	7485	7237	3634
Av. total no. adult stomach worms	3282	1306	2104
Haemonchus contortus	972	273	375
Ostertagia ostertagi	1443	516	686
Trichostrongylus axei	867	517	1043
Av. no. intestinal larvae	0	263	306
Av. no. stomach larvae	25	106	1620

* Significant at the 5% level between drylot and semi-drylot.
** Significant at the 1% level between drylot and pasture.
[a] Number of nematode eggs per gram of feces, expressed in the average for entire period of both years' tests combined.
[b] Intestinal worms—*Cooperia punctata* and *C. oncophora*. A few *Trichostrongylus colubriformis* and *Nematodirus* spp. are included, but they composed less than 1% of the total adult worm load.

pastured groups. The daily forage dry matter intakes averaged 15.8 and 15.9 lb. per head for the high and low protein groups, respectively. Similar forages during this same period averaged 17% DP (McCullough, 1955). Based on intake and forage DP, plus the DP fed in the dry feed, the average daily DP consumption was calculated to be 3.60 and 3.34 lb. per head for the high and low protein groups, respectively. The average daily TDN intake was calculated to be 15.8 and 15.5 lb. per head for the above pasture groups when the dry feed was added to the forage intake. This was considerably higher than the TDN intake of the dry or semi-drylot cattle. Forage clippings were taken every 14

days throughout the test; the crude protein for the forages ranged from 31.2% to 19.0% with an average of 24.5%.

The fed rations were consumed by all calves from hay racks and feed bunks. The limited amount of forage in the semi-drylots was closely grazed at all times, however, since the calves in these lots had plenty

TABLE 2. PARASITISM IN BEEF YEARLINGS AS RELATED TO LEVEL OF PROTEIN FEEDING

Items	High protein	Low protein
No. cattle on test	33	33
Av. initial weight (lb.)	408.8	405.5
Av. final weight (lb.)	679.1	664.4
Av. daily gain (lb.)	2.00	1.95
Av. of egg counts[a]	609	456
No. cattle exam. postmortem	12	12
Av. total no. adult worms	7669	9030
Av. total no. larvae	300	1247
Av. total worm burden	7969	10277
Av. total no. adult intestinal worms[b]	5085	7153
Av. total no. adult stomach worms	2584	1877
Haemonchus contortus	810	270
Ostertagia ostertagi	957	806
Trichostrongylus axei	817	801
Av. no. intestinal larvae	204	175
Av. no. stomach larvae	96	1072

[a] Number of nematode eggs per gram of feces, expressed in the average for entire period of both years' tests combined.

[b] Intestinal worms—*Cooperia punctata* and *C. oncophora*. A few *Trichostrongylus colubriformis* and *Nematodirus* spp. are included, but they composed less than 1% of the total adult worm load.

of dry feed, they did not graze closely around their fecal droppings in the lots.

During the period of each test, the calves were weighed and fecal egg counts were made every 28 days. Large numbers of eggs were counted by the dilution technic, and small numbers by the flotation method of Stoll (1930). The egg counts are shown as the average egg count per animal in each type of lot (table 1) and on high and low protein (table 2) for the entire periods of both years. Postmortem studies were made at the end of the experiments and the number of the different species of worm parasites was estimated by the quantitative postmortem technic for the recovery of helminths by Porter (1942). Each year the worm loads of two typical calves from each of the six groups were

determined, the basis of selection of these calves being their age, weight, and fecal parasite egg count. Although worm loads at necropsy were determined for only about one-third of the calves, the sampling was considered to be adequate to give meaningful conclusions. The tables present the combined results of both years' work.

Results

Relation of Forage Availability to Internal Parasitism

With the availability and consumption of greater amounts of green forage, progressing from none on drylot to limited amounts on semi-drylot and to unlimited amounts on pasture lots, there was a decrease in the total number of worms and number of adult worms, but an increase in the number of larval worms, recovered from the test animals examined at postmortem; weight gains increased with the amount of forage (table 1). There was a statistically significant difference at the 5% level of probability between the number of larval worms recovered from the calves on semi-drylot and drylot (table 1, upper part); the number recovered from the calves on pasture was over five times the number recovered from those on semi-drylot. Although larval stomach worms were recovered in significantly larger numbers from the calves on pasture than from the animals on drylot or semi-drylot (table 1, lower part), the number of larval intestinal worms recovered from the animals on pasture was not much higher than the number from the calves on semi-drylot. It appears from the data that the calves on drylot ingested very few larvae. However, as the availability and consumption of forage increased on semi-drylot and on pasture, the average number of parasitic larvae recovered increased in a proportionate manner.

The availability and consumption of increasing amounts of green forage increased weight gains (significant at the 1% level between pasture and drylot). Though not significant, the average daily weight gain of those animals in semi-drylot was slightly above those in drylot, probably due to the limited amount of grazing available in the semi-drylot. However, such a difference in gain might not be obtained should weather conditions particularly favorable to the development of infective larvae cause a relatively heavier degree of parasitism in animals in a semi-drylot. Although the worm loads carried by the calves were low, and the differences in worm loads between animals for the three types of lots were small, the better gains (table 1) were associated with lower total worm loads, especially in adult worms.

Although both the total number of adult worms recovered (table 1, upper part) and the number of adult intestinal worms (table 1, middle part) decreased with increase in forage consumption, and the animals from drylot also yielded the most adult stomach worms (table 1, middle part), the calves from semi-drylot yielded fewer adult stomach worms than those from pasture. All three species of stomach worms were present in least numbers in the calves from the semi-drylot. The calves from drylot had more *H. contortus* and *Ostertagia ostertagi* but fewer *Trichostrongylus axei* than the calves from pasture.

Though the reasons for these findings are not clear, the recovery of comparatively large numbers of adult worms from the drylot calves indicates that feedlot steers should be treated with anthelmintics at the start of feeding to obtain better parasite control and thus tend to improve performance from the drylot rations. About one-third of the adult worms recovered from the calves in drylot were stomach worms which are wholly or partially susceptible to phenothiazine. Herlich *et al.* (1954) have reported in critical tests that phenothiazine given therapeutically was 100% effective against *H. contortus* and *T. axei*, and from 42 to 97% effective against *O. ostertagi*. Their results agreed generally with previous work by Swanson *et al.* (1940) and Porter (1941). The effectiveness of therapeutic doses of phenothiazine or any other anthelmintic against the cooperids in the small intestine is usually considered to be negligible.

Since steers coming directly from pasture to feedlot normally harbor immature stomach worms, against which therapeutic doses of phenothiazine are less effective than against adults, it might be advantageous to treat steers at the beginning of the feeding period and again after about 2 weeks. Within this period most of the larvae would have matured and become susceptible to the action of phenothiazine. Experiments are needed to determine the advantage of such a program.

Relation of Level of Protein Feeding to Internal Parasitism.

The calves on low protein had a larger total number of worms and more adult and more larval worms than those on high protein (table 2, upper part). Differences, including gains, were not statistically significant. Although the animals on low protein had more adult intestinal worms than those on high protein, they had fewer adult stomach worms that the latter animals (table 2, middle part). The calves of the two groups had essentially similar numbers of adult *O. ostertagi* and *T. axei*,

but those on high protein had three times as many *H. contortus* as those on low protein. The number of larval intestinal worms in animals of the two groups was about equal, but those on low protein yielded 10 times as many larval stomach worms (table 2, lower part), and the number of adult and larval stomach worms combined was greater in the animals on low protein. The most striking finding was the consistent recovery of more larval stomach worms from animals on low protein from all three of the different types of lots. An average of 50 larvae was found in the fourth stomachs of the calves on low protein in drylot as compared with none in their controls on high protein, while the average numbers of larvae recovered from calves from sem-drylot on low and high protein diets were 650 and 88, respectively. The animals on low protein rations from the pasture lots had an average of 3,040 larval stomach worms, while those on high protein had an average of 812.

The consistently lower average recoveries of larval stomach worms from calves on high protein cannot be fully explained on the basis of digestible protein (DP) intake. As previously stated, there was about a 33% difference in DP between the groups on high and low protein in drylot and semi-drylot. However, there was only a slight difference in DP between the groups on pasture. Therefore, under the conditions of this experiment, the effect of level of protein feeding on parasitism was not clear.

Summary

The differences in numbers of parasitic larvae recovered from animals in three types of lots appeared to be related to the availability and consumption of forage. Calves from drylot (no grass) had the lowest number of larvae and the highest number of adult worms, while calves from semi-drylot (limited grass) and pasture lots had significantly higher numbers of parasitic larvae and lower numbers of adult worms at postmortem.

The drylot and semi-drylot animals on high protein had lower numbers of larval stomach worms than those on low protein. The animals from pasture on high protein also had a much lower larval stomach worm population than those fed less protein; but, this latter difference could not be related to protein consumption because the pasture provided an excess of protein to both high and low protein groups.

There appeared to be an inverse correlation between average daily gains and average total worm loads of calves on the different treatments and levels of protein feeding but the results were not conclusive.

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE FORTY EIGHTH ANNUAL MEEING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meetings are scheduled to be held at the Hotel Sherman in Chicago, Illinois, on November 23 and 24, 1956. Abstracts have been submitted for the following papers.

Breeding and Genetics Section

R. C. CARTER, *Chairman*

PHENOTYPIC FORMS AND GENETIC RELATIONSHIPS OF THE BOVINE DWARF COMPLEX. P. W. Gregory, *University of California.*

Several markedly different phenotypic forms of bovine dwarfs have been reported in cattle. The types included are short-headed (snorter), long-headed (Baker *et al.*, 1951), and two different Shorthorn types currently designated as III_A and III_B, the latter characterized by a heavy body with short legs. All were considered by Gregory (1955). These and perhaps others were observed by Koger *et al.* (1955). Crosses of the short-headed with the long-headed type have been made within the Angus and Hereford breeds, between the two breeds, and with Herefords and the III_A type of Shorthorn dwarf, resulting in 14 early maturing comprest-like progeny subnormal in size, designated as V_C, and 2 dwarfs of the short-headed type. One dwarf appeared from the cross within the Angus breed and the other from the Hereford $\times$ Angus mating. Matings between the long-headed Angus dwarf and the Shorthorn (III_A type) produced 2 comprest type (V_C) and 1 short-headed dwarf progeny. When all the F_1 comprest type (V_C) were backcrossed to short-headed dwarfs the resulting progeny were: short-headed dwarfs 15, and comprest type (V_C) 5, a ratio of 3 to 1. When the F_1 comprest were backcrossed to long-headed dwarfs the progeny observed were: short-headed dwarf 3, long-headed dwarf 1, and comprest 3. When the III_B type Shorthorn bull was mated to comprest type Herefords produced from dwarf carrier stock, 11 progeny were produced: short-headed dwarf 3, long-headed dwarf 2, type III_B 3, and comprest 3. These results clearly indicate that all the dwarf phenotypes tested are a part of the same genetic complex and that modifying genes are involved which differentiate specific dwarf phenotypes.

IDENTIFICATION OF THE PROCESS RESPONSIBLE FOR THE SHORT-HEADED HEREFORD DWARF BASED ON ANATOMICAL STUDIES. W. S. Tyler, L. M. Julian and P. W. Gregory, *School of Veterinary Medicine, University of California.*

Skeletal material from 64 Hereford cattle was examined by quantitative anatomical techniques to determine the nature and location of the process responsible for the typical short-headed (Gregory's type I_A) Hereford dwarf. Visual examination of the appendicular skeletons of dwarfs did not reveal obvious mal-

formations. The stage of fusion of 23 epiphyseal lines of the appendicular skeleton was found to be nearly similar in dwarf and normal Herefords of the same age. A series of 65 measurements was made on the appendicular skeletons to determine proportionality and the relative involvement of width, total length, diaphyseal length, and epiphyseal length. Disproportionalities were evident when dwarf and normal Herefords of similar age or of similar body weight were compared. The disproportionalities were most prominent in the metacarpal bones of young dwarfs. Reduced diaphyseal lengths are responsible for these disproportionalities. Evidence was presented indicating the reduction in length of the diaphyses or primary centers of ossification occurred in utero. A microscopic examination of the metacarpal epiphyseal lines from 6 normal and 14 dwarf Herefords under 2 months of age revealed changes most similar to those reported in mild hypoplastic achondroplasia. A comparison was made of the characteristics of achondroplasia and of the typical short-headed Hereford dwarf. It was concluded that a mild form of hypoplastic achondroplasia is the process responsible for this type of dwarfism.

SYSTEMATIC STUDIES ON THE ANATOMICAL EXPRESSION OF BOVINE DWARFISM. L. M. Julian, W. S. Tyler and P. W. Gregory, *School of Veterinary Medicine, University of California.*

In a study of 78 skulls of phenotypically normal and short-headed dwarf Hereford cattle the spheno-occipital synchondrosis of the dwarf was found to close within the first week of life in contrast to the normal closure age of 24–36 months. This lesion is pathognomonic for achondroplasia. An intermeidate group of phenotypically normal animals with fusion times of 8–17 months has been encountered. The peristent bulge of the forehead of the dwarf is due to a tendency toward internal hydrocephalus and a disparity between body size and brain size. A face shortening feature centering in the vicinity of the lacrimal bone is present in the short-headed dwarf and produces the characteristic prognathism of this type of dwarf. Vertebral changes, in addition to those described by other investigators, have been observed. It is suggested that all alterations of the vertebrae are due to a basic growth deficiency of the primary centers of ossification of the vertebrae, consistent with the achondroplastic nature of the dwarfing process. Quantitative anatomical investigations of the muscular, digestive, urinary, genital and endocrine systems are being undertaken.

THE "D" SYSTEM OF BOVINE BLOOD GROUPS. Clyde Stormont and Yoshiko Suzuki, *School of Veterinary Medicine, University of Calif.*

Previous studies (Stormont *et al.*) in another laboratory led to the discovery of the blood group systems A-H, B, C, F-V, J, L, S-U, Z and H′, and to the tentative assignement of the rare bovine blood factors M and Z′ to respective systems independent of the first nine. In the past few years we have had the opportunity in this laboratory to re-develop a complete set of blood typing reagents for all the recognized blood factors in these eleven systems. In the process numerous new reagents were developed. As expected most of these new reagents cross react with phenogroups within the complex B system. One of these, however, appeared to be reactive with a phenogroup(s) independent of those in the recognized systems. We have designated this new blood factor and blood group system by the symbol D in accordance with an agreement among laboratories that participated in the Second Bovine Blood Typing Conference. To date we have produced anti-D only by immunizing rabbits and in only one antiserum have these antibodies been of sufficient titer to be considered reliable for routine

typing. The frequency of the allele(s) for D computed on random samples of 97 Ayrshires, 143 Brown Swiss, 455 Guernseys, 242 Jerseys and 588 Holstein-Friesians is, respectively, 1.00, 1.00, 0.72, 0.66 and 0.97. From this it is apparent that D, the most highly frequent bovine blood factor so far recognized, is of relatively little use in practical applications of these tests. The development of reliable dosage reagents for D would considerably enhance its utility.

ENVIRONMENTAL FACTORS AFFECTING WEANING WEIGHTS OF CALVES AT THE FLORIDA EVERGLADES STATION. H. V. Clum, R. W. Kidder and M. Koger, *University of Florida and Everglades Experiment Station.*

The effect of four environmental factors on 180-day weights was determined from growth data collected over a 25 year period. Male calves averaged 345.6 lb. and females averaged 320.4 lb. The difference in weight due to sex became greater as mean weights increased. Weights of heifer calves were adjusted to male equivalent by multiplying by 1.08. The most productive ages of dam were found to be from five to ten years of age. Calf weights were adjusted to mature dam equivalent by adding 63, 35, 12, 5, 3, 8, 18, 34, 53, and 53 lb. to calves from cows aged 1, 2, 3, 4, 11, 12, 13, 14, 15, and 16 years respectively. The adjusted mean 180-day weights showed a significant month of birth effect. March calves were heaviest, being 31 lb. above the 25-year mean. September calves were 36 lb. lighter than the mean. The data were adjusted for month of birth effect by adding −12, −18, −21, −17, −8, 0, +8, +12, +15, +11, +4, and −5, lb. to weights of calves born during the twelve months, January through December, respectively. Year effect varied from −51 lb. for 1942 to +51 lb. for 1949.

GROWTH RESPONSE OF ANGUS, BRAHMAN, AND DEVON CATTLE AND VARIOUS CROSSES OF THESE BREEDS IN THE SUB-TROPICAL CLIMATE OF THE FLORIDA EVERGLADES. R. W. Kidder, John Liddon, H. V. Clum and M. Koger, *Everglades Experiment Station and University of Florida.*

Devon cattle have been maintained at the Everglades Stations since 1931. In 1946 Angus and Brahman herds were added and studies were initiated cross-breeding the Brahman with both the Devon and Angus breeds. A marked heterosis effect on growth to 180 days resulted from the various Brahman-Devon crosses. Calves from crossbred dams by crossbred sires were lighter than F_1 calves or calves from crossbred dams by purebred sires, suggesting that this heterosis effect was not carried over into mothering ability. In the Angus-Brahman groups, heterosis effects were marked in both growth rate of calves and mothering ability of dams. No crossbred Angus sires were used. The mean adjusted 180-day weights of calves of different groups, including all breeds and crosses were as follows: Purebred calves 336 lb; calves from inter-se crossbred matings 361 lb; F_1 calves 379 lb.; backcross calves 386 lb.; calves from rotational crossbreeding 392 lb. Crossbreeding resulted in a significant increase in 180-day weights of calves. Post-weaning growth data will also be presented.

DRY-LOT PERFORMANCE OF BRAHMAN AND BRAHMAN-SHORTHORN CROSSBRED STEERS. Fentress M. Peacock and W. G. Kirk, *Range Cattle Experiment Station, Ona, Florida.*

Four feeding trials, consisting of four breed groups of steer calves in each trial, have been completed. Breeding of calves in the four lots was as follows: Lot 1, ¾ Shorthorn–¼ Brahman; Lot 2, ½ Shorthorn–½ Brahman; Lot 3, ¾ Brahman–¼ Shorthorn; Lot 4, purebred Brahman. There were 15 calves in

Lot 1 and 16 in each of the other three lots. Average age of calves at beginning of trials in Lots 1, 3 and 4 was 249 days and in Lot 2, 253 days. Each breed group was fed in dry lot for 140 days a ration of Pangola hay grain mixture and citrus molasses. The grain mixture consisted of 55 parts citrus pulp, 30 parts cottonseed meal (41%), 10 parts corn meal and 5 parts ¾" cut alfalfa. Calves were fed two ounces of cod liver oil per week and had free access to Range Station mineral. Lot 1 made an average daily gain of 1.94 lb., and Lots 2, 3 and 4 made 2.00, 2.01 lb., respectively. Lot 1 required an average of 491 lb. TDN per 100 lb. gain, while Lots 2, 3 and 4 required 486, 454 and 438 lb., respectively. The average carcass grade of Lot 1 was, U. S. Low Choice; for Lot 2, U. S. High Good; for Lot 3, U. S. Good; for Lot 4, U. S. Low Good.

THE RELATIONSHIP OF COMBING YIELD OF MAIN SORTS OF INDIVIDUAL FLEECES TO OTHER TRAITS OF TARGHEE SHEEP. Mary E. Hourihan, Joseph G. Powers and Wendell H. Kyle, *U. S. Dept. of Agr., Agricultural Research Service, Animal and Poultry Husbandry Research Branch, Dubois, Idaho and Beltsville, Maryland, in cooperation with the Idaho Agricultural Experiment Station.*

Main matchings or largest sorts of Targhee yearling fleeces from 84 rams and 118 ewes sheared in 1950 and 211 ewes sheared in 1951 at Dubois, Idaho, were processed individually into top at Beltsville, Maryland. Information obtained included top yield, noil yield, percent top of clean wool and percent noil of clean wool. Top yield and noil yield were negatively correlated (—0.84 for ewes and —0.93 for rams). Fleece and matching finenesses or grades, measured or visual, were positively associated with top yield and negatively associated with noil yield. Among ewes, correlation coefficients ranged from 0.23 to 0.30 for fineness with top yield and from —0.28 to —0.33 with noil yield. Staple length was positively correlated with top yield (0.29) and negatively with noil yield (—0.29). Top yield relationships to sample clean yield, matching clean yield and card yield were positive, while noil yield relationships were negative, and all were moderately low. Top yield was positively associated with grease fleece weight and clean fleece weight (0.28 and 0.32), while noil yield was negatively associated (—0.31 and —0.33). Correlations of body weight with top and noil yields were low but significant. Low, non-significant relationships existed between top and noil yields with type, condition, face covering, neck folds and weanling index. Correlations of percent top and percent noil with other traits were similar; however, card yield was more closely related to percent top than to percent noil. Correlations among rams followed the same general trend, but varied more, possibly because of smaller numbers.

THE RELATIONSHIP OF SCOURING AND CARDING YIELDS OF MAIN SORTS OF INDIVIDUAL FLEECES TO OTHER TRAITS OF TARGHEE SHEEP. Francis E. White, Thomas D. Watkins, Jr., Russell L. Clark and Lowell O. Wilson, *U. S. Dept. of Agr. Agricultural Research Service, Animal and Poultry Husbandry Research Branch, Dubois, Idaho and Beltsville, Maryland, in cooperation with the Idaho Agricultural Experiment Station.*

Processing qualities, through scouring and carding, of main matchings from yearling Targhee fleeces were studied on 84 rams and 119 ewes sheared in 1950, 212 ewes sheared in 1951, and 232 ewes sheared in 1952, at Dubois, Idaho. Processing information obtained at Beltsville, Maryland, included clean yields of the main sort of matching, yield of card sliver and handle score. Matching clean yields of both rams and ewes were closely related to side sample clean yields obtained at

Dubois as shown by correlation coefficients of 0.76 and 0.72 respectively. Significant but low positive correlations were found between matching clean yield and staple length, clean fleece weight, side grade, breech grade, fleece grade (ewes only), condition, type and weanling index (ewes only). Significant and equally low negative relationships were found with face covering (rams only), grease fleece weight, body weight, and neck folds score. Low and non-significant correlations were obtained with diameter, variability of diameter, diameter grade, breech grade score and yearling ram index. Card yield showed low and in most cases non-significant, correlations with other traits. Handle or softness score showed significant negative correlations with clean yield of the main sort and side sample and with type and condition scores. Significant positive correlations were obtained with diameter, variability of diameter, diameter grade, card yield, body weight and weanling index. These indicate that softer wool is associated with higher clean yields, finer and more uniform fiber diameters, lower card yields, lighter body weights, and poorer indexes, type, and condition scores.

NITROGEN AND PHOSPHORUS UTILIZATION DURING PREGNANCY IN THE SUCROSE-FED RAT AS RELATED TO HORMONE TREATMENT. K. A. Kendall and R. L. Hays, *University of Illinois.*

Earlier studies in this laboratory indicated that progesterone administered to the female rat fed a diet of sucrose and water, maintained pregnancy with 7.12 viable young per mating observed at autopsy on the 20th day after mating as compared with 1.1 viable young in the non-treated rats, similarly fed. This led to the present study in which 3 groups of 5 mated female albino rats each, were placed on the day of mating on a diet of sucrose and distilled water. Group 1 served as the control, group 2 received 5 mg. progesterone daily and group 3 received 4–6 I.U. prolactin daily. Seven urine collections were made from each animal with each collection representing 72 hours of excretion. Pregnancy was maintained for 21 days in: 2 females of group 1; 5 in group 2 and 4 in group 3. Urinary nitrogen and phosphorus excretion rates were similar in all groups depending upon the reproductive state. Urinary nitrogen levels in period 3 were 49% of those in period 1 and remained at this level in the non-pregnant females but in the pregnant females, in the 7th period, levels increased to 152% of period 1. Urinary inorganic phosphorus levels in period 3 were 45% of those in period 1 and increased slightly in the non-pregnant females but in the pregnant females in the 7th period levels increased to 153% of period 1.

EFFECTS OF PROGESTERONE ON EMBRYONAL MORTALITY OF RATS AND SWINE. P. H. Sammelwitz, P. J. Dziuk and A. V. Nalbandov, *University of Illinois.*

The possibility that early embryonal mortality may be due to a deficiency of progesterone was tested on rats and swine. Forty rats were injected with 4, 6 and 8 mg. of progesterone daily for 18 days beginning on the day following mating. Embryonal survival was 83% in the controls and ranged from 81–83% for the three treated groups. Twenty rats were treated with 0.5, 1.0, 1.5 and 2.0 mcg. of estrogen (ECP) daily for 13 days. In all cases estrogen was detrimental to implantation or embryonal survival, which, in females becoming and remaining pregnant ranged from 59 to 62% in the treated females and which was 79% in the control group. Thirty-five gilts were randomly assigned to five groups, four of which were treated with progesterone at rate of 50, 100, 200 and 400 mg. daily for about 26 days after mating. Injections began on the day following mating.

At the time of slaughter 92% of the ova had survived in the control group, 87% in the 50 mg. group, and 64% in the 100 mg. group. In some of the sows getting 200 mg. and in all of the sows getting 400 mg. the corpora lutea were completely degenerated by the time of autopsy and could not be counted. In contrast, corpora lutea of rats treated with relatively higher doses of progesterone throughout pregnancy, remained grossly and histologically normal. It is concluded that under conditons of this experiment progesterone is not beneficial in reducing early embryonal mortality in sows.

A PRELIMINARY REPORT ON PRESERVATION OF BOVINE SEMEN AT ROOM TEMPERATURES. N. L. VanDemark and U. D. Sharma, *University of Illinois.*

At present semen is stored at low temperatures which makes refrigeration an absolute necessity in artificial insemination units. Attempts have been made to preserve bovine semen at room temperatures with a view to eliminating the need for refrigeration. The following techniques have been employed: 1) A dialysis technique as described by VanDemark and Couturier, 2) daily removal of supernatant fluids from the storage tubes (containing 1:10 dilution of semen) and addition of fresh fluids, 3) daily addition of antibacterial agents to the storage tubes. Maximum sperm survival at temperatures varying from 21°–33° C. with techniques 1, 2 and 3 so far as been 7, 10 to 15, and 7 days respectively compared to 4 to 6 days in control tubes. Since the specific nutrient requirements for sperm survival are not known, a search for a suitable basic solution of known composition was made. Isosmotic solutions of NaCl, $NaHCO_3$, $Na_3C_6H_5O_7$, KCl, $MgSO_4$, $CaCl_2$ and glucose were tried in various combinations in the presence and absence of antibacterial agents (sulfanilamide, streptomycin and penicillin). The presence of antibacterial agents improved longevity. The solutions containing $Na_3C_6H_5O_7$ as a major constituent have been found to be superior to other solutions tried. Apparently the need for a particular nutrient and its optimum level depends on the technique employed and varies with the sample and the method of handling semen.

A DIALYSIS TECHNIQUE FOR SEMEN PHYSIOLOGY STUDIES. N. L. VanDemark and L. R. Couturier, *University of Illinois.*

Reports in the literature indicate that sperm survive many days in the ligated epididymis of laboratory animals. This suggests that dialysis techniques to supply nutrients and remove waste products might be valuable in preserving sperm without refrigeration. A simple scheme was devised which permitted the storage of bull semen in a permeable membrane with a nutrint medium slowly passing by. The arrangement used kept the semen from coming into direct contact with the diluent and allowed withdrawal of portions of the sample at any time. Bacterial growth was reduced by means of antibacterial agents (usually penicillin and streptomycin) in the medium. Rate of passage of the nutrient medium was regulated with needle valves. Using this technique with yolk-citrate, yolk citrate-skimmilk, skimmilk and blood-derived media at room temperature resulted in longer sperm survival than obtained in test tube controls. At room temperature, undiluted controls were dead within approximately 24 hours, while the same samples in the permeable membrane lived for about a week. Diluted controls of the same samples at 5° C. lasted 5 to 6 days. Although sperm in the dialysis bag at room temperature lived longer than diluted controls at 5° C., sperm life was short in the dialysis bag at 5° C. Gassing with O_2 and CO_2 shortened sperm survival using the dialysis technique, but gassing with N_2 did not change survival time.

PROTEIN LEVELS FOR GROWING BOARS ON PASTURE VS. CONCRETE DRYLOT. V. C. Speer, E. L. Lasley, G. C. Ashton, L. N. Hazel and D. V. Catron, *Iowa Agricultural Experiment Station.*

A summary of unpublished data from this station showed that boars individually fed free-choice consumed a higher proportion of supplement to corn than barrows and gilts. This made it desirable to determine the effect on weight gains and feed per lb. gain of boars fed different levels of protein. Thirty-six Poland China and 36 Landrace boars were individually fed complete rations of 10, 13, 16, 19, 22 and 25% protein from 30 to 195 lb. live weight. Three boars from each breed were fed on each protein level, on concrete and on pasture. The 12 boars fed the 10% protein rations failed to complete the test. A statistically significant protein level × concrete vs pasture interaction for gain and feed per lb. gain precludes overall comparisons of concrete vs. pasture and protein levels. The interaction resulted from the low daily gains (1.28 lb.) and high feed per lb. gain (3.28 lb.) of the 13% protein pigs on concrete compared to 1.68 lb. and 2.69 lb., respectively, for the 13% protein pigs on pasture. The daily gain and feed per lb. gain were not greatly different for the pigs fed 16% protein or more whether on concrete or pasture; the gain and feed per lb. gain values were 1.70 and 2.72, and 1.68 and 2.61 lb. for pigs fed on concrete and pasture, respectively. Over the range from 13 to 25% protein the average live probe measurements showed a statistically significant linear decrease with increased protein levels.

EFFECTS OF THE SNORTER DWARF GENE ON THE LUMBAR VERTEBRAE AND METACARPUS IN HEREFORD CALVES AT BIRTH. K. P. Bovard, L. N. Hazel, and M. A. Emmerson, *Iowa State College.*

The combined length of the six lumbar vertebrae was measured from individual radiographs of 19 Snorter dwarf and 131 normal Hereford calves at birth. The mean difference between normal and dwarf calves in lumbar length and birth weight was 1.31 cm. and 13.5 lb., respectively. The normal calves were classified by sex; by radiographic findings as (1) normal, (2) slightly irregular, and (3) definitely abnormal; and by pedigree or progeny test results as (1) known heterozygote, (2) possible heterozygote, and (3) presumed homozygous normal. Differences in lumbar length between groups in the main classes were adjusted for general size differences using birth weight as an independent variable. The regression of lumbar length on birth weight, $b=0.046$, was significant ($P<.01$). Radiographs of the metacarpus were available for 71 normal calves. Thirty-five of these were anterior-posterior views and 36 were lateral views. Adjusted differences in length of metacarpus followed the same general trends as those found in the analysis of lumbar length.

RADIOGRAPHIC EXAMINATIONS OF LUMBAR VERTEBRAE AS A METHOD OF DETECTING CARRIERS OF THE SNORTER DWARF GENE. L. N. Hazel, M. A. Emmerson and K. P. Bovard, *Iowa State College.*

Radiographs of the thoracolumbar spinal region of young calves have been examined as a method of detecting dwarfism. All of the 40 to 50 Snorter dwarfs examined have exhibited severe longitudinal compression and irregular protrusion of the body below the usual epiphyseal-diaphyseal union. Many of the heterozygotes exhibit abnormalities of a less extreme nature. All of the 12 normal calves having one dwarf parent had abnormal vertebrae varying from slight to extreme degrees of abnormality. Dairy calves have had only normal vertebrae with an obvious smooth, half-moon curvature of the lower body when seen in ventral

profile. From the limited progeny-testing which has been done on calves x-rayed while still young, it is evident that some vertebrate classifications do not agree with genotype. Homozygous normal animals are occasionally classified as abnormal for minor variations in vertebrae development which apparently are not at all associated with the Snorter dwarf gene. Heterozygotes have also been classed as having completely normal vertebrae but this misclassification is relatively infrequent. One other dwarf gene, having a different syndrome of abnormalities and apparently at a different locus, has an obvious but less severe effect upon the vertebrate than the Snorter dwarf gene.

EFFECT OF PLANE OF NUTRITION UPON THE REPRODUCTIVE PERFORMANCE OF BOARS. R. H. Dutt and C. E. Barnhart, *University of Kentucky.*

Nine weanling Hampshire boars were divided into three groups on the basis of weight and litter relationship and placed on different levels of feed intake. One group received 100%, the second group 70%, and the third group, 50% of N. R. C. recommended allowances of a complete ration for growing boars. The boars were placed on feed July 14 at an average age of 60 days and remained on their respective feeding level for 312 days. Age at onset of puberty was determined and during April each boar was bred to three gilts that were slaughtered 25–28 days after breeding. At the end of the breeding period an ejaculate of semen was collected from each boar in an artificial vagina each day for a period of one week. Motility, volume, sperm cell concentration and percent abnormal sperm cells were determined. Average age at puberty for the 100%, 70% and 50% groups was 203 days, 212 days and 219 days, respectively. Average daily gain and average final weight for the three groups were: 1.13 and 382 lb.; 0.85 and 293 lb.; and 0.69 and 243 lb., respectively. Percentages of corpora lutea represented by normal embryos in all gilts bred were 54.9, 63.1 and 55.7, for the three groups respectively. For pregnant gilts only, the percentages were 75.7, 74.7 and 70.2 respectively. These percentages do not differ significantly. For the 7-day semen collection period the average volume of semen produced per ejaculate for the three groups of boars was 193.3, 163.3, and 137.1 ml. respectively. Average sperm cell concentration was 173,000, 168,000, and 195,000 cells per mm^3, respectively. Volume was the only semen characteristic which differed significantly among the three groups.

ESTIMATION OF GENIC VARIANCE IN INBRED POPULATIONS. Walter R. Harvey and Franklin A. Graybill, *U.S.D.A. and Oklahoma A. and M. College.*

Changes in the additively genetic (genic) variance due to inbreeding was determined by Wright in 1921. Dickerson (1943) showed that if the sire and dam components of variance are estimated from an inbred line formed by using a regular inbreeding system, each are expected to contain $\frac{1+f'-2f}{4}$ of the genic variance; where f' is the inbreeding of the sires and dams and f is the inbreeding of the progeny. It can also be shown that $\frac{1+f'-2f}{4}$ of the genic variance is still present in these components of variance even though the mating scheme has been irregular, *provided* that equal frequencies exist in the data. In this case, f' and f refer to the average inbreeding for the parents and offspring, respectively. When the inbreeding system has been irregular and the frequencies are unequal the inbreeding coefficients of the sires and dams and the covariances among them must be weighted in order to obtain unbiased estimates of the genic variance from the

sire and dam components of variance. The proper weights to give the numerator relationship coefficients was determined by making use of the following mathematical model: $y_{ijk}=\mu+\frac{1}{2}g_i+\frac{1}{2}g_{ij}+\sqrt{\frac{1}{2}g_{ij}}+\epsilon_{ijk}$ where the g's and their coefficients refer to the contribution of genic effects from the sire, dam, and Mendelian chance, respectively; μ is the population mean; ϵ_{ijk} are the random environmental effects; and y_{ijk} is the observation on the k^{th} progeny out of the j^{th} dam and by the i^{th} sire. Covariance among the g_i and g_{ij} elements exist when inbreeding has been practiced. The expectations of these covariances and the method required to obtain unbiased estimates of genic variance in the general case will be presented.

SELECTION FOR HIGH AND LOW FATNESS IN DUROC AND YORKSHIRE SWINE. H. O. Hetzer and J. H. Zeller, *U. S. Department of Agriculture.*

An experiment designed to investigate the effects of selecting for a single character in swine was started at Beltsville in 1954 by separating from each of a group of 82 Durocs (34 boars, 48 gilts) and 103 Yorkshires (50 boars, 53 gilts) foundation stocks for 1) a line high in fatness, 2) a line low in fatness and 3) an unselected control line. Fatness was measured by average of 3 backfat measurements at live weight of about 175 lb. Selection of foundation animals for high and low lines was made entirely within litters after foundation stocks for Control lines had been randomly selected from same litters. Except for obviously unthrifty pigs, all litters tested included every pig weaned and body measurements reflecting differences in conformation were obtained on all pigs when measured for fatness. The numbers of test pigs represented in the first generations of High, Low and Control lines were 57, 64 and 54 for Durocs and 54, 56 and 54 for Yorkshires, respectively. Selection for high and low backfat thickness gave differences of .22 and .14 inches between foundation stocks for High and Low line Durocs and Yorkshires, respectively. The resulting differences between first generation High and Low line pigs were .04 and .09 inches, giving estimates of .18 and .64 for the heritability of intra-litter differences for Durocs and Yorkshires, respectively. Corresponding estimates derived from regressions of offspring on mid-parent were .42 for Durocs (25 d.f.) and .38 for Yorkshires (21 d.f.). In both breeds selection for high backfat thickness tended to favor the retention of shorter, wider and lower bodied pigs. Selection of foundation stocks for Low lines also favored shorter, wider and lower bodied pigs in Yorkshire but longer, narrower and taller bodied pigs in Durocs.

HERITABILITY OF CARDING AND COMBING YIELDS OF MAIN SORTS OF INDIVIDUAL FLEECES AND RELATED TRAITS OF TARGHEE SHEEP. Clair E. Terrill, Wendell H. Kyle, Mary E. Hourihan and Francis E. White, *U. S. D. A., Agricultural Research Service, Animal and Poultry Husbandry Research Branch, Dubois, Idaho and Beltsville, Maryland, in cooperation with the Idaho Agricultural Experiment Station.*

Targhee yearling fleeces studied were from 83 rams and 119 ewes sheared in 1950, 212 ewes in 1951 and 232 ewes in 1952 at Dubois, Idaho. Individual fleeces were sorted by a commercial sorter. The main or largest sort of each fleece was processed to top. Heritability estimates were obtained from half-sib correlations based on the variances between and within sires for each type of mating (inbred lines and top-crosses) within sex and year, adjusted to a non-inbred basis. Averages were obtained for each sex by weighting each year and type of mating group estimate by the reciprocal of its squared standard error. Heritability estimates from

rams, with small numbers, vary widely and none of the averages exceeds twice its standard error. Ewe heritability estimates also vary but the averages are reasonably comparable to available previous estimates. High average heritability estimates from 0.67 to 0.53 were obtained for handle, matching yield and clean fleece weight. Moderately high average estimates from 0.43 to 0.29 were found for clean yield, face covering, staple length, fleece grade, noil yield, percent noils, body weight, weanling index, matching grade, diameter, diameter grade, type, grease fleece weight and breech grade. Side grade, condition, neck folds, and variability of diameter had moderately low average estimates from 0.24 to 0.20, but all were more than twice their standard errors. Low average heritability estimates from 0.18 to 0.01, probably not significantly different from zero, were obtained for top yield, percent top, card yield and breech grade score.

COMPARATIVE REPRODUCTIVE PERFORMANCE OF A GROUP OF MILKING SHORTHORN COWS THAT WERE MILKED VS. A GROUP THAT NURSED CALVES. J. N. Wiltbank and A. C. Cook, *U.S.D.A.*

The breeding records of 84 Milking Shorthorn cows which were milked at least one lactation and used as nurse cows at least once were sutdied to determine the effect of nursing a calf on reproductive performance. The average length of the 162 service periods (interval from calving to conception) for the milked cows and of the 245 for the nursed cows was 100 and 153 days ($p.<.01$), respectively. The service period was divided into the interval between calving and first heat and the interval from first breeding to conception. The average length of the former was 74 days and 107 days ($p.<.01$), and for the latter 25 and 46 days ($p.<.01$) for the milked and nursed cows, respectively. The average number of services per conception was 1.63 for the milked cows and 1.82 for the nursed cows ($p.>.05$). The possibility that the differences between the milked cows and the nursed cows was caused by age was checked by arranging the service periods in order (1st, 2nd, etc.) within the milked and within the nursed cows. An analysis showed that as a cow became older the service period tended to shorten. Rectal palpation of the genital organs of the cows this past year showed that the average length of the interval from calving to first corpus luteum was about 20 days shorter in the milked cows and that the milked cows on the average had one quiet ovulation between calving and first heat compared to two for the nursed cows.

THE OCCURRENCE OF ESTRUS AND THE CONCEPTION RATE IN A HERD OF 450 BEEF COWS BRED DURING A LIMITED BREEDING SEASON. J. N. Wiltbank, M. J. Burris and B. M. Priode, *Animal & Poultry Husbandry Research Branch, U.S.D.A., and Virginia Agricultural Experiment Station.*

The apparent breeding dates of 160 Angus, 134 Hereford, and 173 Shorthorn cows at the Front Royal, Virginia, station were determined during an 80-day breeding season by painting the bull's briskets and checking the cows twice daily for marks. Eight percent of the cows became pregnant without marks being observed and errors through false marking are suggested by the facts that 20% of the 230 estrual cycles observed were under 16 days in length and 30 (7%) cows were marked after they became pregnant. Rectal palpations indicated that 404 (86.5%) of the cows became pregnant with the percentage conception rate on first, second, third and fourth service being 62.4, 58.5, 41.2 and 38.9, respectively. The average number of services per conception ranged from 1.28 to 4.62 for the 22 bulls used. Of the 63 cows which did not become pregnant during the 80-day breeding season, 7 (22.2%) were bred once; 19 (30.2%) were bred twice; 12 (19.0%) were bred three times; and 11 (17.5%) were bred 4 times. The average

interval between calving and first heat could not be accurately determined from these data. However, when it is assumed that cows not bred during the first 21 days of the breeding season have not been in heat previously the cows which have an interval over a certain period in length can be calculated. These data showed that 6.6% of the intervals were 100 days or more in length; at least 11.1% were over 90 days; and 16.5% over 80 days in length.

EFFECT OF DIURNAL CHANGES IN AMBIENT TEMPERATURE ON HAIR AND SKIN TEMPERATURE OF JERSEY AND HOLSTEIN CATTLE. R. E. Stewart and S. Brody, *University of Missouri.*

Three lactating Jersey and three lactating Holstein cows were subjected in the Climatic Laboratory to three weeks of diurnal temperature rhythm from 50° F. to 110° F. The temperature peak occurred between 2 and 4 pm; the temperature trough between 4 and 6 a.m. Hair and skin temperatures were measured by copper-constantan thermocouples mounted as shown in Missouri Agr. Exp. Sta. Res. Bul. 561. An electronic-balance potentiometer was used to indicate the various temperatures. Temperatures were taken on back, side, and belly of each animal and averaged by breed. A total of 30 sets of measurements were made during the 3-week period, timed to obtain sampling throughout most of a 24-hour period. Results showed that hair and skin temperature lagged behind the ambient (air) temperature by 1 to 2 hours. At 110° F. ambient, hair and skin temperatures merged at about 102° F., but as the ambient declined, the skin and hair continued rising to about 103° F. Breed differences in hair and skin temperature were small, although Jersey skin temperature was higher after the peak ambient temperature has passed and stayed slightly higher for several hours. It is theorized that surface temperatures of cattle lag behind changing ambient temperature because of their large thermal capacity (weight time specific heat); therefore, cattle can withstand very high day temperatures provided the nights are cool. Approved by the Director as Journal Paper No. 1643.

VARIATIONS IN THE PHYSIOLOGICAL RESPONSE TO STRESS IN DWARF AND NORMAL BEEF CATTLE. Charles W. Foley, John W. Massey and John F. Lasley, *University of Missouri.*

Fifty-nine animals from two different beef breeds were used in a series of studies to determine possible causes of dwarfism in beef cattle, and in an attempt to develop a method of identifying normal appearing animals carrying the dwarf gene. Normal (pedigree-clean) animals, known carriers of the dwarf gene and dwarfs from both the Angus and Hereford breeds were included in the study. Insulin tolerance tests in which insulin was injected intravenously and the blood sugar level determined at regular intervals for periods up to 12.5 hr. following this treatment showed definite differences between dwarf and normal appearing animals. The tests indicated that the blood sugar level dropped much more quickly and to a lower level in the dwarfs and failed to return to a normal level as quickly as in normal appearing animals. This indicated a possible abnormal pituitary or adrenal hormone response to stress in the dwarfs. The increase in the white cell count in the blood following insulin was then used to test for an adrenal cortical hormone response to stress. Dwarfs responded very little, pedigree clean animals showed a rapid and extreme response whereas known carriers of the dwarf gene were intermediate in their response to this treatment. Differences between the three groups were highly significant when tested statistically. Contribution from the Missouri Agri. Experiment Station, Journal Series No. 1659. Approved by Director.

INHERITANCE OF NIPPLE NUMBERS IN SWINE AND ITS RELATIONSHIP TO PERFORMANCE. Arthur D. Allen and John F. Lasley, *University of Missouri.*

The inheritance of nipple numbers was studied in the progeny of Purebred Landrace, Poland, Duroc and crossbred Landrace × Poland sows. Significant differences in nipple numbers were found between animals of the different breeds and crosses. Landrace pigs averaged one pair of nipples more than pigs from the Poland breed or from Landrace × Poland sows mated to Duroc boars. Progeny from the reciprocal cross of Duroc sows mated to Landrace × Poland boars averaged almost two pairs of nipples less than the purebred Landrace pigs. The heritability of differences in nipple numbers was calculated using the covariance technique for determining the intra-sire regression of offspring on dam. This is an estimate of heritability in the narrow sense and is thought to measure mostly the variations due to additive effects of genes. The heritability estimate determined by this method was approximately 59%. Undoubtedly, other types of gene action other than that of an additive nature were present, but no attempt was made to measure these. Male pigs exceeded female pigs slightly in average nipple numbers although these differences were not significant. The number of nipples the dam possessed was significantly correlated with the size of her litter at farrowing on an intra-breed basis, but the interbreed correlation coefficient was not significant.

HERITABILITY OF DIFFERENCES IN TWO ECONOMICALLY IMPORTANT TRAITS IN SWINE. V. Balakrishma Reddy and John F. Lasley, *University of Missouri.*

Rate of gain and backfat thickness were studied in 436 Landrace × Poland pigs from reciprocal crosses farrowed in two seasons. Season sex and type of feeding (pasture or dry lot) were found to significantly influence both of these traits and corrections were made on the original data before heritability estimates and correlations between relatives were determined. Heritability estimates for rate of gain calculated by means of the intra-sire regression of offspring on dam were only 2% for spring pigs, 16% for fall pigs and 4% for pigs from both seasons combined. The coefficients of regression of offspring on the mean of the sire and dam gave values of .31, .20 and .21 for spring, fall and both seasons combined, respectively. Heritability estimates for backfat thickness from the intra-sire regression of offspring on dam were 49%, 18% and 35%, respectively, for pigs farrowed in the spring, fall and both seasons combined. Regression coefficients of .16, .18 and .10 were obtained for pigs farrowed in the spring, fall and both seasons, respectively, by determining the regression of offspring on the mean of both the sire and dam. Of the several family relationships studied for both traits, the correlations between the progeny and the average of the dam and her littermates were fairly high and consistent. A positive association was found between rate of gain and backfat thickness ($P<.05$) in the spring-farrowed pigs, whereas a negative association was observed between the same traits ($P<.05$) for pigs farrowed in the fall. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1657. Approved by Director.

SOME GENETIC ASPECTS OF INTRA-UTERINE AND POST-UTERINE GROWTH IN BEEF CATTLE. John F. Lasley and William E. Pugh, *University of Missouri.*

Variations in intra-uterine and post-uterine growth rate and their relationships were studied in 323 Hereford range calves born in a single season. The calves were

sired by eight different bulls. Intra-uterine growth rate was expressed as the average daily gain during a standard 287-day gestation period. All birth weights were corrected to the 287-day standard before average daily gains were calculated. Post-uterine growth rate was expressed as the average daily gain from birth to weaning. Weaning weights were corrected to a 205-day basis. The rate of gain during each period was affected by the sex of the calves, the age of the dam and season of the year in which the calves were born. Corrections were made for each of these factors before the genetic analysis of the data was made. The average daily gain of the calves during gestation was .295 lb. with a standard deviation of .031 and a coefficient of variation of 10.52%. Similar figures for growth during lactation were 1.430, .200 and 13.70. The heritability of differences for these traits was calculated by the paternal half-sib correlation method and was 27% for intra-uterine and 28 for post-uterine growth rate. The correlation coefficients between intra-uterin and post-uterin gains were as follows: Phenotypic, .05; environmental, —.20; and genetic, .72. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1658. Approved by Director.

EFFECT OF TEMPERATURE ON THE GROWTH AND DEVELOPMENT OF ZEBU, MILKING SHORTHORN, AND SANTA GERTRUDIS HEIFERS. D. A. Hartman, Paul Cornelison, A. C. Ragsdale and Samuel Brody, *University of Missouri.*

At 50° F., the three breeds grew at almost the same rate; at 80° F., the Shorthorn growth in weight was retarded so that they weighed about 200 lb. less than the Zebu or Santa Gertrudis at age 12–16 months. A striking developmental breed difference at 50° and 80° F. related to the ratio of surface to weight. At 50° F., the surface area per unit weight was always greater in the Zebu and Santa Gertrudis than in the Shorthorn. At 80° F., however, the surface area was greater in the Zebu and Santa Gertrudis only to 10 months of age; thereafter, the surface area per unit weight in the Shorthorns increased with increasing age above those of the Zebu and Santa Gertrudis due to changes in body form associated with their reduced appetite at high temperatures. It thus seems that a high ratio of surface to weight tends to be associated with stressfully-high temperatures either by long-range evolutionary selection, as illustrated by the tropically-evolved Zebu cattle having exceptionally large peripherae (dewlap, ears, etc.), or by change in the body form of individuals subjected to stressfully high temperatures as occurred in the Shorthorn heifers. There is no such individual adaptation of hair growth to high temperatures. While the outdoor Shorthorns shed their hair on approach of seasonally hot weather (by photo-periodic mechanisms), the maintenance and growth of the indoor Shorthorn's hair was not affected by high temperatures. Mo. Agr. Exp. Sta. Journal Series No. 1655. Approved by Director.

THE INFLUENCE OF AGE AND FLUSHING TREATMENT ON REPRODUCTION OF RANGE EWES. A. S. Hoversland, J. L. Van Horn, O. O. Thomas and A. E. Flower, *Montana State College.*

A flushing experiment, conducted over a three-year period, involved 644 yearling and 2189 mature range, whiteface ewes (2 to 7 years of age at breeding). Flushed ewes were group fed 0.5 lb. of protein supplement per head per day and grazed on native range forage, during the period 3 weeks prior to and 3 weeks during breeding. Flushing did not insure body weight gain or weight maintenance but did cause significant differential in weight compared with controls. The lambing percent (lambs born per 100 ewes alive at lambing) for the flushed, yearling ewes

was 105.3, 104.1 ** and 95.7%, and 109.7, 81.8 and 93.2% for control, yearling ewes for years 1952, 1953 and 1954, respectively. The lambing percent for the flushed mature ewes during these years was 148.6,* 137.8 ** and 159.1**% as compared to 139.0, 123.3 and 141.1% for the control ewes, respectively. The combined data indicates that flushing yearling ewes increased lambing percent by 5.6 *%, reduced the number of single births by 5.6% and increased the number of multiple births by 5.6*%; the percentage of ewes dry was the same. The combined data for mature ewes indicates that flushing significantly influenced the following factors by the amounts given: (a) increased lambing percentage by 13.7**, (b) reduced number of dry ewes by 2.4*%, (c) reduced the number of single births by 7.9**%, and increased the number of multiple births by 10.3**%. The response of yearlings to flushing was less pronounced and more irregular than of mature ewes.

THE RELATIONSHIP OF REDUCED GLUTATHIONE-HEMOGLOBIN RATIOS TO RATES OF GAIN IN IMMATURE BEEF CATTLE. H. O. Kunkel, *Texas Agricultural Experiment Station.*

Reduced glutathione and hemoglobin levels have been determined in bloods of beef calves in gain evaluation tests over a period of three years. The repeatability of the reduced glutathione to hemoglobin ratio (GSH/Hb), an expression of GSH concentration in the erythrocytes, is higher than that for the GSH level in whole blood. Variations in GSH/Hb are probably more indicative of any physiological variation in cattle than are the GSH levels in the blood. The coefficient of correlation between GSH/Hb values and initial body weight is small but significant statistically and is of a greater magnitude than is the coefficient of correlation between GSH/Hb and age. The GSH/Hb is linearly related to the previous rate of gain to a small extent and appears to be indicative of the severity of dietary restriction, especially in older animals, *i.e.*, animals 350–410 days of age. Product-moment correlations between GSH/Hb and subsequent rates of gain in feed lot are generally not significant statistically. Significant curvilinear coefficients of correlation, ranging from 0.409 to 0.591, have been obtained with groups of Brahman, Charbray, and Angus cattle. The curvilinear coefficients of correlation were small and non-significant for groups of Herefords and Santa Gertrudis cattle.

A STUDY OF FACTORS ASSOCIATED WITH INDIVIDUAL DAILY RANGE IN RECTAL TEMPERATURE OF MILKING HOLSTEIN AND JERSEY COWS. Robert R. Shrode, Troy B. Patterson, Jr. and Eduardo H. Vega, *A. & M. College of Texas.*

Rectal temperature was recorded for 56 Holstein cows and 68 Jersey cows in milk during the summer of 1955. Observations were made at both the morning and evening milkings for a period of ten days. From these data daily ranges were computed for each cow. Significant correlations ranging from 0.36 to 0.53 were observed for daily temperature range with concurrent milk production, stage of gestation, and stage of lactation. These correlations are of sufficient magnitude that adjustment of daily temperature range values needs to be done before genetic studies of body temperature regulation can yield reliable results, particularly if sire effects are confounded with effects which are correlated with daily temperature range.

* $P<0.05$; ** $P<0.01$.

HEREDITARY AND ENVIRONMENTAL VARIATION IN THE WEIGHTS AND GROWTH RATES OF SUFFOLK LAMBS UNDER FARM CONDITIONS. D. W. Cassard and W. C. Weir, *University of California.*

An analysis was made of factors affecting birth weight, weight at 70, 120, and 240 days and the three rates of growth between the first four weights from 1952–1956 in the purebred Suffolk flock at the University of California at Davis. Sex difference was not significant at birth, but was important in all weights and rates of growth thereafter. Early lambs had an advantage in weight and growth rate from 70 to 120 days which decreased by 240 days and disappeared by yearling age. Singles were heavier than twins at birth and grew faster to 70 days but slower from 70 to 120 days than twins. In females all important weight difference between twins and singles was lost by 240 days. However, in males a large and significant difference reappeared at yearling time. The three sires in this study caused significant weight differences only in yearling males. Year differences were found only in 240 day weights and growth rate from 120 to 240 days. Age of dam effected 70 and 120 day weights and growth to 70 days (curvilinear). Offspring-dam regression estimates of heritability for weights ranged from .09 at birth to .41 at 120 days. Estimates for growth rates were .40, .18, and .63. Estimates of repeatability and heritability of the production of ewes in total weight of lambs at birth, 70 and 120 days will also be reported.

THE EFFECT OF NUTRITIONAL ENVIRONMENT ON BLOOD GLUTATHIONE LEVEL IN CATTLE. J. F. Kidwell, V. R. Bohman, M. A. Wade and J. E. Hunter, *University of Nevada.*

An association between glutathione—GSH—concentration and rate of cell proliferation, protein synthesis and adult size has been established. Evidence relating to the influence of environment on blood GSH level in cattle is inconclusive. This experiment was designed to determine the main effect and interactions of Diethylstilbestrol, Chlortetracycline, and graded levels of animal fat in the ration on blood GSH level in long yearling Hereford steers. A $2 \times 2 \times 3$ factorial design involving 48 steers was employed. There were two levels each of diethylstilbestrol and chlortetracycline and three levels of fat. There were no significant effects of ration on blood GSH, total cell count, percent hemoglobin or body weight after 40 days on feed. A significant decrease in blood GSH, total cell count and percent hemoglobin and an increase in body weight was observed. Highly significant positive correlations of the order of .65 to .75 were observed between blood GSH, total cell count and percent hemoglobin initially and after 40 days on feed. There was no relation between blood GSH and body weight. The correlation between initial blood GSH level and blood GSH level after 40 days was 0.74.

SPERM OUTPUT OF RABBITS EJACULATED EITHER ONCE A WEEK OR ONCE A DAY. A. T. Gregoire, R. W. Bratton and R. H. Foote, *Cornell University.*

Eight Dutch type rabbits were randomly assigned to two groups and semen was collected with an artificial vagina once-a-week from each for a 13-week preliminary period. During this period the average volume, percent motile, sperm concentration and motile sperm per ejaculate for the bucks in Group I was 0.45 ml., 66%, 403×10^6 and 137×10^6, respectively, and for the bucks in Group II was 0.83 ml., 68%, 407×10^6 and 243×10^6, respectively. The Group II bucks

then were placed on a once-a-day semen collection regime and the Group I bucks continued on the once-a-week regime. During the first 26 weeks the average volume, % motile sperm, sperm concentration and motile sperm per ejaculate was 0.42 ml., 62%, 317×10^6 and 98×10^6, respectively, for the bucks collected once-a-week, and 0.48 ml., 60%, 208×10^6 and 54×10^6, respectively, for the bucks collected once-a-day. Eighty-nine percent of the ejaculates in the once-a-week group contained motile sperm as compared to 97% in the once-a-day group. On a weekly basis the average number of motile sperm collected per buck was 98×10^6 for the once-a-week group and 376×10^6 for the once-a-day group. There was no apparent downward trend in sperm output, sexual interest or body weight during the 182 days of the once-a-day collection regime. These results suggest that better utilization of the sperm producing potential of males may be possible by more frequent collection of semen.

THE USE OF ESTIMATED VARIANCE COMPONENTS IN DESIGN OF FERTILITY EXPERIMENTS WITH BOVINE SEMEN. H. O. Dunn, C. R. Henderson and J. T. Godfrey, *N. Y. Artificial Breeders' Coop., Inc., and Cornell University.*

The 60- to 90-day nonreturns from 44,527 first services to 12 NYABC Holstein bulls were subjected to variance component analysis using Eisenhart's Model II for taking expectations of sums of squares. Punched cards and IBM equipment were utilized for computation of sums of squares for estimating technician variance (σ_a^2), bull variance (σ_b^2), semen sample or collection variance (σ_c^2), variances of all first and second order interactions, and the random error variance (σ_e^2). There were 12 collections from each of the 12 bulls. Inseminations were performed by 184 technicians. The estimated variance components and their percent of total variance were as follows: $\sigma_a^2 = .0012$ (0.59%), $\sigma_b^2 = .0008$ (0.40%), and $\sigma_e^2 = 0.1978$ (98.5%). The interactions, as well as σ_c^2, were essentially zero. The mean nonreturn rate was 72%. These results indicate that, for most fertility experiments conducted at this station, there is no advantage of using the split-ejaculate technique or for controlling on bulls and technicians. The magnitude of the number of services for any subclass or treatment appears to be of utmost importance due to the large random error, σ_e^2. These estimated variance components can be utilized for designing and planning experiments and for determining the power of the analysis of variance test. Illustrations have been prepared to show the number of inseminations required in different experimental designs to detect, with a high degree of probability, treatment differences of specified magnitude. For one design, approximately 100,000 services would be required to be sure (95% confidence) of detecting (at the 5% significance level) treatment differences as small as one percentage unit.

COMPARISON OF A THREE-BREED ROTATIONAL CROSSBREEDING PROGRAM WITH AN INBRED AND AN OUTBRED POPULATION IN SWINE. G. M. Bolick, H. A. Stewart and E. U. Dillard, *N. Carolina State College.*

A comparison was made between an established three-breed rotational cross, an inbred Tamworth population, and an outbred group of purebred Durocs. The comparison made on the three breeding systems included data on reproductive ability of the sows and preweaning traits of the pigs from 1062 pigs farrowed in a nine year period (1947–1955). Mean values showed an advantage for the

crosses in all traits considered. However, the traits that were measured at weaning showed a greater advantage for the crosses than the traits measured at birth. Analyses of variance, using the data on litter and individual bases, indicated that the effect of mating systems in years was highly significant for number weaned, number farrowed alive, and litter weight at 56 days. The number farrowed and weight at birth showed the same trend of superiority for the three-breed crosses but not of the magnitude indicated for the other characters. The large amount of variation from year to year encountered between mating systems prevented any firm conclusions regarding superiority of a mating scheme when considered over the entire period of study. However the results indicate an advantage for the crosses since 1952 for number weaned, weaned weight, and litter weight at 56 days. Survival percentages showed a lower mortality for the three-breed rotational crosses, from birth until weaning than for the Durocs or Tamworths.

TOP CROSS RESULTS WITH INBRED BULLS. Earle W. Klosterman, A. L. Moxon and L. E. Kunkle, *Ohio Agricultural Experiment Station.*

For three years, progeny of Nebraska Line 1, Montana Line 1, and Outbred Hereford bulls have been compared. Each of two different bulls from each line each year were bred to ten grade Hereford cows. Birth weights, weaning weights, and weaning type scores were obtained. Following weaning, the calves were fattened on a standard ration in dry lot in groups according to sex and line of breeding. All calves were fed, as nearly as possible, to choice slaughter grade. There were no significant differences between lines of breeding in birth weight or 182-day weaning weight. However, steers sired by Montana Line 1 bulls made significantly larger gains from 90 to 182 days of age. Weaning type scores of Montant Line 1 steers and heifers averaged significantly lower than Nebraska Line 1 or outbred calves. Steers and heifers from either inbred line gained significantly faster than progeny of outbred bulls when full fed a fattening ration in dry lot. Concentrates required per unit of gain averaged lower for calves sired by inbred bulls but with the limited number of observations from group feeding, these differences were not significant. There were no significant differences between lines in carcass grade. Detailed slaughter and carcass cut-out data were obtained on a total of 8 steers and 8 heifers from each line of breeding.

VITAMIN A DEFICIENCY AND REPRODUCTIVE PERFORMANCE OF FEMALE SWINE. D. E. Ullrey, E. Wynn Jones, Willis D. Gallup and J. C. Hillier, *Oklahoma A. & M. College.*

The possibility that sub-clinical vitamin A deficiency may develop in milo-fed swine under drought conditions prompted the following study. Fifteen, sexually-mature, crossbred gilts were fed a basal ration containing 0.68 p.p.m. of carotene for 20 days. They were then allotted to two treatments from litter outcome groups, eight continuing to receive only the basal ration and seven receiving an additional supplement of 300 I.U. of vitamin A_1 acetate per kg. of body weight. Liver biopsies were performed on the 15th, 35th, and 69th day of the experiment. A liver sample was also obtained at slaughter. Blood was obtained biweekly for hematology and plasma vitamin A determination. A test for night-blindness and direct ophthalmoscopic examination of the fundus oculi was performed monthly. Regularity of estrus was observed by checking the gilts every two days with a vasectomized boar. All gilts were bred as soon as possible after 105 days on

experiment and slaughtered 24 to 30 days later. Initial liver stores of vitamin A (20.0±11.9 p.p.m. ($\bar{X}$±S.D.)) decreased in the basal group to 5.3±5.3 p.p.m. and increased in the supplemented group to 304.6±37.3 p.p.m. Plasma levels decreased from 17.2±3.7 mcg. per 100 ml. to 15.8±4.5 mcg. per 100 ml. in the basal group and increased to 38.4±5.7 mcg. per 100 ml. in the supplemented group. Plasma vitamin A was not a sensitive indicator of the deficiency state, although low plasma levels tended to be associated with nyctalopia, ocular lesions, increased susceptibility to infection, increased embryonic mortality, and genital hypoplasia. Histopathology of tissues removed from the gilts and the embryos will be reported.

HERITABILITY OF LID PIGMENTATION AND CANCER EYE SUSCEPTIBILITY IN CATTLE. David E. Anderson, Doyle Chambers and Jay L. Lush, *Cancer Eye Study Section of The University of Texas M. D. Anderson Hospital and Tumor Institute, Houston.*

The relationship between amount of pigmentation on the skin of the eyelids and the occurrence of cancer eye, heritability of lid pigmentation, and heritability of cancer eye susceptibility were studied in Hereford cattle. A definite correlation ($P<.01$) was found between lid lesions and lid pigmentation. Animals with lid lesions and no lid pigmentation were more numerous than expected if lesions and pigmentation occur independently. Partially pigmented lids had correspondingly fewer lesions, while no lesions were ever observed on completely pigmented lids. There was only a slight indication of any association between lesions at other sites on the eye and lid pigmentation ($.20<P<.40$). Heritability estimates of lid pigmentation ranged from .41 to .50. Mass selection for an increased amount of lid pigmentation should be effective. This would be expected to reduce the incidence of lid lesions, but not have much effect on the frequency of lesions on the cornea, nictitans and caruncle. Heritability of cancer eye susceptibility was found to be .27 for a population which ranged from 3 to 15 years of age, and .41 for the portion of the population which ranged from 5 to 15 years of age. Susceptibility was measured by a score based on the age of cancer occurrence. The results indicate that the incidence of cancer eye could be reduced by breeding for increased resistance to cancer eye and for more pigmentation on the skin of the lids.

PRODUCTIVITY OF BEEF COWS AS APPRAISED BY CALF WEIGHTS AT 112 AND 210 DAYS OF AGE. C. Dale Hoover, Doyle Chambers, J. A. Whatley, Jr. and D. F. Stephens, *Oklahoma Agricultural Experiment Station.*

The 112-day weights of 1110 calves produced by 303 beef cows and the 210-day weights of 1151 calves produced by 301 of these cows from 1950 through 1955 in four station herds were analyzed to determine repeatability estimates for calf weights at the two ages. The weights were adjusted to the standard ages by use of correction factors obtained from the data. The calf weights were likewise adjusted for differences due to sex, age of dam, season and treatment. Repeatability estimates were obtained by two methods: by the intraclass correlation obtained from an analysis of variance, and by the regression of records subsequent to the first on the first record. The repeatability estimates obtained for calf weights at 112 days of age were .29 and .35 as determined by the intraclass correlation and the regression methods, respectively. Estimates obtained for 210-day weights were .32 by the intraclass correlation and .34 by the regression method. The correlation between weights at 112 days and 210 days of age for calves produced by the same cow was .86. In view of these results, it would seem that one could cull cows

effectively for productivity at a time earlier than at weaning. This would permit some flexibility in management practices which might be to the economic advantage of the breeder.

SOME FACTORS AFFECTING DIFFICULTY AT PARTURITION OF TWO-YEAR-OLD HEREFORD HEIFERS. Delbert G. Moore, Doyle Chambers, J. A. Whatley, Jr. and W. D. Campbell, *Oklahoma Agricultural Experiment Station.*

Large numbers of Hereford heifers have been bred to calve first at two years of age in the range area of the Southwest. Surveys indicate that approximately 50% of these heifers require help at calving and that 15% of the calves and 5% of the heifers are lost at parturition. Studies conducted by this station from 1951 to 1954 included calving scores for 668 two-year-old Hereford heifers and the birth weights of their calves wheich were sired by Hereford and Angus bulls. The identity of individual sires was known for 234 of these calves. The ages and weights of the dams at breeding and at calving were also known for the dams of 234 of the calves. The remaining 434 calves were produced in a large commercial herd in which sire identification was not possible. Results of this study indicated that heifers dropping bull calves experienced considerably more difficulty than those dropping heifer calves. The bull calves were 4 to 5 lb. heavier than heifers. Heifers bred to large-type Angus and to large-type and medium-type Herefords dropped calves which were 3.7 lb. heavier than those bred to medium-type and small type Angus and small-type Herefords. Less calving difficulty was experienced by the heifers and fewer death losses occurred when the calves were sired by the smaller more refined bulls of both breeds. The heavier heifers at breeding time produced calves somewhat heavier but experienced less difficulty at parturition in spite of larger calf size.

EFFECT OF CALVING DATE ON SUBSEQUENT CALVING PERFORMANCE IN BEEF CATTLE. Martin J. Burris and B. M. Priode, *Virginia Agricultural Experiment Station and U.S.D.A.*

A high annual calf crop percentage is an essential part of the profitable beef cattle enterprise. Failure of cows to calve is one of the chief problems in securing a satisfactory calf crop. Calving records of Angus, Hereford, and Shorthorn cows at the Beef Cattle Research Station at Front Royal, Virginia from 1950 to 1956 were analyzed to determine the effect of calving date on subsequent calving performance. Three determinations made from these data include: (1) percent of cows calving each 20 day period during the calving season which failed to calve the following season; (2) comparison of previous calving dates of all cows which failed to calve with the previous calving date of all cows which calved in both years; (3) and the association between calving dates of cows when these calvings occurred in successive calving seasons.

The regression of percent of cows failing to calve on previous calving date was 6.9% per 20 day period or 6.9% more cows not calving for each delay of 20 days in previous calving date. The calving date in the previous year of cows which failed to calve was 7.1 days, 16.3 days, and 14.2 days later than the calving date of contemporary cows in the first year which calved in both seasons in the Angus, Hereford and Shorthorn herds respectively. The correlation between successive calving dates was .33, .34, .49 for the Angus, Hereford, and Shorthorn herds respectively. These observations indicate that selection for early calving date would result in an immediate increase in calving percentage when the breeding season is limited to approximately 90 days.

HERITABILITY OF GROWTH RATE AND MARKET GRADE IN MUTTON LAMBS. W. S. Hundley, Jr. and R. C. Carter, *Virginia Agricultural Experiment Station.*

Estimates of heritability of rate of gain from birth to weaning and of slaughter grades at market weight were obtained from paternal half sib analysis of data from 943 lambs sired by Hampshire and Southdown rams out of grade ewes. The data were adjusted for the effects of sex, age of dam and type of rearing (single or twin). By breed, heritability estimates and their standard errors were .37±.15 and .04±.14 for Hampshires and Southdowns respectively for daily gain. Heritability estimates and standard errors for market grade were .28±.15 and .31±.33 for the two breeds respectively. Phenotypic correlation between daily gain and market grade for the Hampshires was .46 and for the Southdowns, .32. Based on the phenotypic correlations it appears that with Southdowns market grade is not as dependent on rate of gain as with Hampshires. The results indicate that heritability for daily gain and market grade in Hampshires may be high enough to be of economic importance, and that selection for one trait would tend to improve the other. This work indicated that heritability for daily gain may be low for the Southdown breed.

THE EFFECT OF BREED OF SIRE ON BODY SIZE OF LAMBS AT BIRTH IN MUTTON TYPE SHEEP. Haley M. Jamison, R. C. Carter and C. M. Kincaid, *Virginia Agricultural Experiment Station.*

The effect of breed of sire on body weight and three linear measurements of lambs at birth was studied using data on 967 grade lambs over a 10-year period sired by 60 rams of seven breeds. The data were adjusted for environmental effects by least squares analysis within breed. Adjusted birth weights ranged from 8.54 to 9.38 pounds, the rank in descending order by breed of ram was Hampshire × Southdown, Hampshire, Columbia, Southdown, Dorset, Corriedale, and Shropshire. Adjusted head circumference ranged from 10.52 to 11.20 inches. The rank by breed of sire being Hampshire × Southdown, Columbia, Shropshire, Corriedale, Dorset, Hampshire and Southdown. In chest circumference, the range was 14.64 to 15.41 inches. Rank by breed of sire was Hampshire × Southdown, Columbia, Dorset, Corriedale, Shropshire, Hampshire and Southdown. Wither height ranged from 13.41 to 14.61 inches. Rank in descending order was Corriedale, Hampshire, Columbia, Dorset, Hampshire × Southdown, Shropshire and Southdown. Differences in birth weight and linear measurements among breeds were small but in some cases statistically significant. Not all breeds were used each year; only Hampshire and Southdown rams appeared in all of the years. In making breed comparisons, only the observations within the years in which the particular breeds appeared together were used. Regression analysis of birth weight on the three linear measurements indicated that the relationship was essentially linear. There was no indication that lambs by any breed of sire had proportionally larger head or chest circumference.

FACTORS AFFECTING FETAL PIG WEIGHT LATE IN GESTATION. D. P. Waldorf, W. C. Foote, H. L. Self, A. B. Chapman and L. E. Casida, *University of Wisconsin.*

Eighty litters of 102–108 day-old fetuses from 46 gilts and 34 sows (Duroc, Yorkshire, and Poland China breeds and all crosses of these breeds) were used in this study. Age of dam in gilts appears to be responsible for a greater part of the variability in fetus weight than the dam's carcass weight or backfat thickness. In

sows carcass weight and backfat thickness did not account for a significant variation in fetus or membrane weight; age was not studied. Survival rate, when litter size was held constant, did not have a significant effect on fetus or membrane weight in either sows or gilts; litter size had a marked negative effect. There is no definite evidence to indicate that variation in litter size has any effect on fetus weight other than that exerted through the number of pigs in a horn. In both parity groups a large part of that variability in fetus weight caused by variability in litter size and number of pigs per horn was mediated through variability in membrane weight. The pigs at the extremes of a uterine horn tended to be larger than those toward the middle. A highly significant variability in membrane weight due to intrahorn position was found in both sows and gilts, the membrane at the cervical end tending to be the largest. In both parity groups intraclass correlations indicate that intrahorn position may have less effect on fetus and membrane weight than number of fetuses per horn.

INTERRELATIONSHIPS OF FACTORS AFFECTING LITTER SIZE AND FETUS WEIGHT AND DEVELOPMENT IN SWINE. L. N. Baker, H. L. Self, A. B. Chapman, R. H. Grummer and L. E. Casida, *University of Wisconsin.*

Purbred Chester White and Poland China gilts were bred to boars of the same or opposite breed. Gilts returning to heat were rebred, slaughtered at 3 days and checked for the normality of their reproductive tract, and ova. One hundred nineteen gilts were slaughtered at the 25th day of pregnancy and 26 gilts on the 70th day. Observations were made on the number of corpora lutea, number of live and dead embryos in each horn of the uterus and the weight of each embryo, its membranes and surrounding fluids. Embryo survival (normal, return gilts considered as cases of 100% embryo loss) to the 25th day was 57% and to the 70th day 50%. The analysis of the direct effects (by standard partial regression) of ovulation rate and embryo survival on litter size indicates that survival rate is far more important than ovulation rate (25-day: 0.97 vs. 0.28; 70-day: 1.03 vs. 0.35). Likewise, the analysis of the direct effects of membrane weight and fluid weight on the embryo weight suggests that the fluids are a better indicator of membrane activity (assuming fluids a product of membrane) than membranes themselves at the 25-day stage; at the 70-day stage the reverse is true. The direct effects of three variables—number of embryos per litter, number of embryos per horn and average membrane weight per horn—on average weight of embryos per horn were analyzed. The path of average membrane weight per horn to average fetus weight per horn was the most important of the three variables at both stages of pregnancy (0.59 and 0.63; $P<.01$).

SOME FACTORS INFLUENCING WEANLING TRAITS IN PUREBRED RAMBOUILLET LAMBS. M. P. Botkin, P. O. Stratton and E. K. Faulkner, *University of Wyoming.*

Data on weights and staple length at weaning were available from five purebred Rambouillet flocks in Wyoming on a performance testing program. The work included tests on 1500 lambs. 1020 of these were weaned at an average age of 128 days, the remaining 480 were weaned in the fall at an average age of 202 days. Regression of weight on age at weaning was .47 lb. for the lambs weaned at 128 days, and .26 lb. for those weaned at 202 days. Rams were 9 lb. heavier than ewes in the group weaned at 128 days, and 15 lb. heavier than ewes in the group weaned at 202 days. Single lambs were 14 lb. heavier than twin lambs in the group weaned early, and only 8 lb. heavier than twins in the group weaned later. Twins raised as singles weighed about the same as single lambs. This indicates that sex

differences become greater and that type of birth differences become smaller as the lambs grow older. Age of dam had very little influence on weaning weight, but did influence total production. Production for 2-year-old ewes was lower than that of ewes 3 years old or older primarily because of fewer twins from 2-year-old ewes. Measurements on 1404 of these lambs showed that staple length was largely influenced by age and that little effect was evident because of differences in sex or type of birth.

Nutrition Section

S. L. HANSARD, *Chairman*

THE UTILIZATION AND DIGESTIBILITY OF ROUGH RICE BY SWINE. Kendall W. Scott and E. L. Stephenson, *University of Arkansas.*

Thirty-six weanling crossbred pigs were used to determine the replacement value and digestibility of rough rice as a corn substitute. Corn was replaced at 0, 20, 40, 60, 80, and 100% in lots 1–6 respectively. The six pigs per lot were fed ten weeks on these rations with the 11th week being used for digestion studies. Chromic oxide was used as an indicator of digestibility according to the method of Schürch *et al.* (J. Animal Sci. 11:1952). This indicator was mixed in the ration which was then pelleted to insure equal consumption. Fecal samples were obtained on 3 alternate days, dried, and composites prepared and analyzed for fat, ash, crude fiber, protein and chromic oxide. The total weight gains were 600, 604, 672, 637, 673, and 626 lb. for the respective lots. The average daily gain was 1.30, 1.31, 1.45, 1.38, 1.46, and 1.35, while the pounds of feed per lb. of gain were 3.35, 3.64, 3.52, 3.52, 4.20, and 3.67 respectively for lots 1–6. The fecal fat percent decreased with increasing levels of rough rice, also the percent of fecal protein was decreased with the increased rough rice levels. Rough rice substitution in this trial gave gains equal to or superior to corn. Digestibility data will be presented.

THE DIGESTIBILITY OF RATION NUTRIENTS BY THREE- VS. SEVEN-WEEK OLD PIGS. L. E. Lloyd, E. W. Crampton and V. G. MacKay, *Macdonald College (McGill University).*

Thirty-two pigs, weaned at two weeks of age, were fed a dry early-weaning ration for a period of 6 weeks. Upon reaching three and seven weeks of age, the apparent digestibility of the ration nutrients was determined for each group of four pigs by the chromic oxide method. The average digestion coefficients for the seven-week old pigs were found to be higher for all the nutrients studied—dry matter, total energy, crude protein, ether extract, and total carbohydrate. The greatest difference and the highest variability was noted for the ether extract fraction. Therefore, 80 pigs, weaned at two weeks of age, were fed the same ration to which 13 different fats or oils were added at the 20% level. Apparent digestibility of ration nutrients was determined as before. Once again, the average digestion coefficients for the older pigs were higher for the same nutrients, and the most pronounced differences occurred in the case of ether extract digestibility. It was noted that there was a progressive decrease in the apparent digestibility of ether

extract when the mean molecular weight of the fatty acids in the fats or oils increased. This decrease was accentuated in the case of the three-week old pigs. These results indicate that there is a marked change in the digestive ability of the young pig prior to 8 weeks of age, particularly with reference to the digestibility of fat.

THE RELATION BETWEEN CERTAIN CHARACTERISTICS OF FATS AND OILS AND THEIR APPARENT DIGESTIBILITY BY YOUNG PIGS, YOUNG GUINEA PIGS, AND PUPS. L. E. Lloyd and E. W. Crampton, *Macdonald College (McGill University).*

In studying the relative nutritional properties of edible oils used in human dietaries, 20 different fats or oils were added individually to a basal ration and fed to pigs, guinea pigs and pups weaned at an abnormally early age. All fat or oil additions were made at the 20% level, and the apparent digestibility of each fat or oil was determined for each animal, or group of animals, within each species. In the case of early-weaned pigs and guinea pigs, a highly significant inverse relationship was found to exist between the mean molecular weight (length of chain) of the fatty acids of the various fats and oils and their apparent digestibility. In fact, approximately 30% of the total variability in the apparent digestibility of the fats and oils by these species was attributable to fatty acid chain length. The relationship between the degree of saturation of the fats or oils and their apparent digestibility by the young pigs and guinea pigs was of minor significance. In the case of early-weaned pups, neither mean molecular weight nor degree of saturation had any significant effect on the apparent digestibility of the fats or oils. This species difference might be of significance when choosing a pilot animal in studies concerning the nutritional properties of edible fats or oils.

THE CALORIE VALUE OF TDN: SWINE STUDIES. E. W. Crampton, L. E. Lloyd and V. G. MacKay, *Macdonald College (McGill University).*

In lieu of the more cumbersome scheme of TDN there is increasing thought being given to the use of "digestible calories" as determined directly by bomb calorimetry on feeds and subsequent fecal residues as a measure of the digestible energy of feeds and rations. One problem raised is the salvage of the extensive TDN figures now on hand. Two terms are wanted,—the digestibility of the gross energy of feeds, and the digestible energy equivalent of TDN,—both of which will have to be estimated in most cases solely from already recorded proximate analyses and/or TDN values. From data accumulated in our laboratory equations have been prepared from which either one or both of these terms may be calculated for such feeds, thus permitting estimation of their digestible calorie yield.

THE INFLUENCE OF THE AMOUNT OF PROTEIN AND ENERGY IN THE RATION OF REPLACEMENT EWE LAMBS ON BODY WEIGHT GAINS AND WOOL PRODUCTION. F. Whiting and S. B. Slen, *Experimental Farm, Lethbridge, Alberta.*

Two experiments were conducted to determine the influence of the level of protein and energy in the ration of replacement ewe lambs on body weight gains and wool production. In each experiment six groups of eight weanling lambs were individually fed rations containing three levels of protein (approximately 8.3, 10.0, and 11.6%). Each protein level was fed at two levels of digestible energy (low and medium). The protein level was increased by substituting linseed oil meal for

wheat and barley and the energy level was increased by substituting corn starch for wheat straw in the ration. On the low energy rations increasing the daily protein intake from 0.13 to 0.16 lb. resulted in a significant increase ($P<0.05$) in the gains made by the lambs, but increasing the daily intake of D.C.P. to 0.20 lb. resulted in no further increase in gain. On the medium level of energy no significant response was obtained by increasing the protein intake from 0.13 to 0.16 lb. However, the high level of protein intake produced a significant increase ($P<0.05$) in body weight gains. Data on wool production were obtained from areas tattooed on the right shoulder of each lamb. It was found that within energy groups only the high level of protein supplementation produced a significant increase in wool growth. However, when energy levels were combined significant increases were obtaind for both the medium and high levels of protein. When the wool production of the different protein intakes were combined it was noted that increasing the level of energy had no significant effect on wool growth.

HIGH LEVEL COPPER FEEDING OF GROWING-FATTENING SWINE. Billy Bass, J. T. McCall, H. D. Wallace, G. E. Combs, Jr., A. Z. Palmer and J. E. Carpenter, *University of Florida.*

Using a basal corn-soybean oil meal type ration fortified with known essential vitamins and minerals the efficacy of feeding high levels of copper to growing-fattening pigs has been investigated. In the first trial 10 pigs were fed the basal ration and 10 pigs were fed the basal ration supplemented with 250 p.p.m. of copper as copper sulfate. For a 10-week feeding period the control pigs gained at an average rate of 1.33 lb. per day and required 3.08 lb. of feed per pound gain. Those fed the high copper ration gained 0.88 lb. per day and required 3.50 lb. of feed per pound gain. One pig on the high copper ration died and upon autopsy exhibited symptoms of copper poisoning. Livers from pigs of the control group averaged 48 p.p.m. of copper (dried ether extracted basis) compared to 1260 p.p.m. for the high copper fed group. A second trial involved 0, 100, 150, and 200 p.p.m. of copper supplementation. Average daily gains and feed required per pound gain for each treatment respectively were 1.54, 3.29; 1.70, 3.51; 1.61, 3.22; and 1.52, 3.26. Analytical data on the content of copper in selected tissues from pigs of the various dietary treatments will be presented as well as information on the effect of high copper feeding on the curing properties of hams and bellies.

STUDIES ON THE PALATABILITY OF ANTIBIOTICS FOR SWINE. D. C. Tomlin, H. D. Wallace, G. E. Combs, Jr. and W. L. Alsmeyer, *University of Florida.*

Three experiments have been conducted to determine the relative acceptability of four crystalline antibiotics—chlortetracycline, oxytetracycline, penicillin V and erythromycin—to weanling pigs. The antibiotics were added to the feed mixtures at a level of 40 gm. per ton and the experiments were of 6 weeks duration. Each pen of pigs in all experiments was offered in separate feeders the various antibiotics. Feeders were rotated at weekly intervals to overcome position preference. The following figures give the relative acceptability of the various antibiotics for the three experiments, respectively, expressed as a percent of the total feed consumed: chlortetracycline—49.6, 66.2, 64.8; oxytetracycline—20.4, 13.2, 9.9; penicillin V—29.6, 14.2, 3.2; erythromycin—0.6, 0.0, 0.0; and no antibiotic—this treatment was not offered in the first experiment, 6.4, 22.1. These results indicate that weanling pigs have a preference for chlortetracycline, strongly dislike erythromycin, and have no particular likes or dislikes for oxytetracycline and penicillin V.

CONSUMPTION AND UTILIZATION BY RATS OF COPPER AND IRON FROM ELEMENTAL COPPER AND IRON SOURCES. L. R. Arrington, *University of Florida.*

Fifty-four rats were housed in stainless steel cages and fed a diet deficient in copper and iron. One group was given access to weighed copper and iron metal plates suspended in the cages. Control rats were fed the same diet without access to metal plates. Loss in weight of plates was taken as a measure of metal consumption. Hemoglobin values, weaning weight of litters, growth and liver copper values were measures of utilization. Weight loss of the plates demonstrated a slight but variable consumption of the metals. Some elemental copper was consumed by rats gnawing the plates, but metals apparently were available also in the oxidized state. Rats of the first generation weaned from stock females were not affected by the deficient diet. These were bred and the offspring continued on the experimental treatments. The number of litters producd was normal in each group; however, approximately one-half of the young from the unsupplemented group died during the suckling period. Comparative results from the supplemented and unsupplemented groups were as follows: Average weaning weight 41 and 35 gm.; weight at six weeks 111 and 92 gm.; hemoglobin 7.0 and 4.1 gm. per 100 ml. Limited determinations of liver copper indicated higher values for the supplemented group, but variations between individuals were large. The results indicate that rats may obtain a part of the copper and iron requirements from elemental sources.

EVALUATION OF THE LIVER BIOPSY TECHNIC FOR USE IN MINERAL NUTRITION STUDIES WITH BEEF CATTLE. H. L. Chapman, Jr. and G. K. Davis, *Everglades Experiment Station, University of Florida.*

The biopsy technic is used quite extensively to obtain samples of liver tissue from beef cattle IN VIVO. Comparisons of blood and liver analyses data from 31 Brahman × Angus heifers and 6 Devon cows, which were subjected to a copper-depletion treatment, indicate liver tissue levels of copper and iron to be of more value than blood hemoglobin or total copper levels in the prognosis of inadequate copper metablism in beef cattle. To evaluate the variability in liver tissue analyses which could be attributed to site of biopsy, thirty livers were obtained from animals which had been sacrificed for experimental purposes. Each liver was divided into 4 areas and two biopsy samples taken from each area by the trocar and cannula normally used to obtain biopsy samples IN VIVO. Copper values of the samples were significantly different between and within areas. There were no significant differences in iron content of the samples attributable to site of biopsy.

RELATIONSHIP OF PREVIOUS MINERAL NUTRITIONAL HISTORY TO BODY STORES OF COPPER AND IRON IN BEEF CATTLE. H. L. Chapman, Jr., *Everglades Experiment Station, University of Florida.*

Six mature Devon cows which had received 0.25 gm. of copper daily during the previous 12 months and six which had received an approximate average daily intake of 0.87 gm. of copper for the previous 6 months were placed on a copper-depletion treatment. Blood hemoglobin, hematocrit and total copper levels were determined every two weeks and the level of iron and copper in the liver tissue every four weeks. Blood and liver analyses data indicate the animals which had previously received the lower level of copper were seriously depleted of copper within a 2–4 week period as compared to an 18–20 week period for those which

previously received the higher copper intake. When maintained on a low copper regime the offspring of the former cows depleted their body stores within a 3–8 week period after birth as compared to an 18–24 week period for the calves whose dams previously received the higher level of copper.

RELATION OF LEVELS OF MOLYBDENUM TO COBALT UTILIZATION IN CATTLE. G. K. Davis, F. H. Jack and J. T. McCall, *Florida Agricultural Experiment Station.*

Molybdenum added to cattle rations at levels of 200 and 400 p.p.m. markedly changed the distribution of vitamin B_{12} in liver and heart tissues. Vitamin B_{12} labeled with $Cobalt^{60}$ was used in these studies. Orally administered $Cobalt^{60}$ was incorporated into vitamin B_{12} in the rumen at greatly differing rates depending upon the molybdenum level of the ration. At the high level of molybdenum very little vitamin B_{12} was formed. Beneficial response, in field trials, to added cobalt when the feed contained high levels of molybdenum, appear to be associated with increased vitamin B_{12} synthesis following increased cobalt consumption.

THE FEEDING VALUE OF C SUGAR AS MEASURED BY PERFORMANCE AND CARCASS DATA. J. F. Hentges, Jr., A. Z. Palmer and G. K. Davis, *University of Florida.*

Data from four experiments are summarized in evaluating C sugar as a beef cattle feed. In a preliminary tolerance test, 30 calves were group fed C sugar in amounts increased by one-half pound every third day until scouring occurred. Five pounds per head was the maximum average daily intake tolerated. Two lots of 15 yearling cattle each were used to compare cracked corn and C sugar as sources of energy in wintering rations. Each lot had access to dry grass pasture, a mineral mixture and a daily supplement of one pound cottonseed pellets. Lot I, which received 4 lb. cracked corn daily, gained 0.73 lb. while lot II, which received 4 lb. C sugar daily, gained 0.81 lb. daily. Seventeen yearling heifers were used to measure the effects of oral dosage and feeding of C sugar in varied amounts and time intervals before slaughter upon liver weights, liver glycogen content (biopsy and post-slaughter), liver palatability, muscle pH, carcass grade and dressing percentage. Lot treatments were 1, control; II, 4 lb. sugar orally 24 hours before slaughter; III, 8 lb. sugar orally in two doses 24 and 48 hours before slaughter; and IV, 4 lb. sugar daily for 28 days before slaughter. Lot IV carcasses graded higher but other criteria revealed no significant differences. Ten heifers were individually fed for six months on rations in which C sugar, grass hay and cottonseed meal supplied all TDN. Efficiency of feed utilization and weight gains were satisfactory.

SUGARCANE BAGASSE IN THE STEER FATTENING RATION. W. G. Kirk, George K. Davis and F. M. Peacock, *Range Cattle Experiment Station, Ona, Florida.*

Bagasse-molasses, containing 30% bagasse and 70% cane molasses, was fed in two steer fattening trials and ammoniated bagasse, protein equivalent of 11.5%, was fed in the second trial. Check steers in Trial 1, fed hay, cottonseed meal, citrus pulp and citrus molasses, had an average daily gain of 3.14 lb. and required 451 lb. TDN per 100 lb. gain. Replacing one-third of the hay and citrus molasses with bagasse-molasses reduced daily gain to 2.79 lb. and increased TDN to 502 lb. Average daily gain was 2.71 lb. and TDN requirement for 100 lb. gain was 483 when one-half of the hay and molasses were replaced with bagasse-molasses. The check ration in the second trial was the same as in Trial 1 except that cane molasses was substituted for citrus molasses. Lot 2 was fed one-half the hay fed Lot 1 and Lot 3

received only a limited amount of hay. This hay and cane molasses was replaced with bagasse-molasses. Ammoniated bagasse was used to replace one-half the hay fed Lot 4, and practically all the hay fed Lot 5, both being given cane molasses. The average daily rations per steer contained from 1.34 to 1.36 lb. digestible protein at the start of the trial. The average daily gains for Lots 1, 2, 3, 4 and 5 were 2.32, 2.51, 2.48, 2.09 and 2.19 lb. respectively and the TDN consumed for 100 lb. gain were 595, 603, 593, 620 and 627 lb.

INTERRELATIONSHIPS OF PROTEIN, LYSINE AND ENERGY IN DIETS FOR GROWING SWINE. R. F. Sewell, R. P. Abernathy and R. L. Tarpley, *University of Georgia.*

Sixty weanling pigs were used in a 2×2×3 factorial experiment in which the main treatment effects were protein level, lysine supplementation and energy level. The basal ration was composed of yellow corn, soybean oil meal, peanut oil meal, alfalfa meal and fortified with vitamins, antibiotic and minerals. Stabilized prime beef tallow was used to vary energy levels. Statistical analysis of the data for the early growth period when the pigs had reached an average weight of approximately 110 lb. showed significantly faster gains for pigs receiving 18% protein diets as compared to pigs receiving 14% protein diets. A highly significant linear growth response due to increased energy also was found during this period. Lysine supplementation (0.1% of the diet) resulted in a highly significant depression in rate of gain during early growth. The energy linear × lysine interaction approached significance. Maximum depression occurred at the low energy level with a slight increase in rate of gain at the highest level. Analysis of the data for the entire growth period to market weights showed the linear growth response to increased energy level to be highly significant throughout the experiment. The magnitude of variation in response due to protein level and lysine supplementation decreased during the latter growth period so that these differences were not significant when the data for the entire experiment were considered. Efficiency of feed utilization improved appreciably with increased energy level. No significant differences were found in live probe backfat measurements.

EFFECT OF CALCIUM LEVEL AND TRACE MINERALS ON THE RESPONSE OF YOUNG PIGS TO UNIDENTIFIED GROWTH FACTORS. J. H. Conrad and W. M. Beeson, *Purdue University.*

Three week old pigs were used in a series of four experiments to evaluate semi-purified diets and to study different sources of unidentified growth factors (UGF) for the young pig. In experiment 1, a diet in which the protein was supplied from casein was superior to a Drackett protein basal. The addition of extra trace minerals and a combination of UGF (3% each of fish solubles, distillers solubles, grass juice, dried whey and 1% of fermentation residue) to the Drackett basal increased gains 35% and 54%, respectively. In experiment 2, extra trace minerals, distillers solubles, grass juice and a fermentation product all gave from 20% to 70% increase in the rate of gain. In experiment 3 and 4 the influence of the calcium level on UGF response was studied. The average daily gains resulting from the addition of 100 ppm. zinc, brewers dried yeast 5% (BDY), distillers solubles 5% (DDS), dried whey 5% (DW), and fish solubles 5% (FS) to a low calcium (0.68%) and a high calcium (1.06%) diet are as follows: Low Ca Basal, 1.02 and High Ca Basal 0.83; Zinc 1.13 and 1.10; BDY 1.11 and 0.97; DDS 1.18 and 1.20; DW 1.15 and 1.05; FS 1.08 and 1.15. Differences in average daily gains between those fed the high calcium basal and 8 of the 10 treated lots were highly significant ($P<0.01$). The unidentified growth factors increased gains 9% to 16%

when added to the low-calcium diet but 17% to 45% when added to the high calcium diet. Data have been obtained to show that a part of the UGF response with young pigs (3 weeks of age) on high-calcium (1.06%) diets appears to be due to the fact that some sources of UGF prevent or greatly reduce the incidence of parakeratosis and thereby enhance the rate of gain.

THE TOLERANCE OF SWINE TO DIETARY LEVELS OF P-AMINOPHENYL ARSONIC ACID. R. A. Notzold, D. E. Becker, F. B. Adamstone, S. W. Terrill and A. H. Jensen, *University of Illinois.*

Three experiments were conducted to determine the tolerance level and toxic effects of p-aminophenyl arsonic acid (AA) in swine. In all experiments the pigs were self-fed *ad libitum* a practical diet consisting of yellow corn, soybean oil meal, steamed bone meal, minerals, and vitamins. In the first test pigs weighing about 100 lb. were fed 0.00, 0.01, 0.02, and 0.04% AA with and without antibiotics in the diet for a period of 63 days. The treatments failed to have any statistically significant effect upon the rate of gain or to have any apparent influence upon feed intake or feed efficiency. However, near the end of the test pigs fed 0.04% AA exhibited a peculiar incoordinated gait. At the conclusion of the test liver samples of representative pigs fed none and 0.04% AA contained 0.08 and 9.00 ppm of As_2O_3 respectively. In the second trial weanling pigs weighing about 40 lb. were fed the same levels of AA for an 89-day period. Again AA levels failed to influence the rate of gain but following 39 days on feed the pigs fed 0.04% AA exhibited stiff rear legs and hocks, stilted and incoordinated gait, and deformed carpal joints. These symptoms became more pronounced during the remainder of the test. Similar, but less severe, symptoms were noted in pigs fed 0.02% AA, but no abnormality was noticed in pigs fed 0.01% AA. In the last test feeding the weanling pig 0.08% AA produced an acute toxicosis which was characterized by depressed feed intake, sanguineous stool, irritability, cannibalism, and complete paralysis. Death occurred following an average of 29 days on feed. There was evidence of a breed difference in the response to high levels of AA.

DRIED WHEY AS A DIETARY INGREDIENT FOR SWINE. D. E. Becker, L. J. Hanson, S. W. Terrill and A. H. Jensen, *University of Illinois.*

High levels of feeding dried whey as a carbohydrate replacement were studied in swine at various stages of growth. With the suckling pig (8 lb.) fed a synthetic diet with casein plus methionine as the source of protein, levels of 0, 30, and 60% dried whey were studied as a substitute for dextrose. There was no significant difference in rate and efficiency of gain, and there was no evidence of a whey-induced diarrhea. With the finishing pig (100 lb.) levels of 0, 5, 10, 20, 40 and 60% dried whey were studied as a starch replacement both in the presence and absence of an antibiotic. A semi-synthetic diet with soybean oil meal plus methionine as the source of protein was used. Level of dried whey did not interact with antibiotic. A level of 60% dried whey produced a depression in rate of gain and daily feed intake and a marked diarrhea, but there was no effect upon the efficiency of gain. All other levels of whey yielded satisfactory performance, although there was some evidence of diarrhea at the 40% level. With weanling pigs, incorporation of 20 or 30% dried whey into the diet as a substitute for corn in a corn-soybean oil meal diet produced a marked decrease in rate of gain and feed intake and a moderate diarrhea. Samples of roller-dried whey yielded a greater rate of gain and feed intake than samples of spray-dried whey when fed to the weanling pig as 30% of a diet which contained casein plus methionine

as the source of protein. Drying method did not affect feed efficiency. The response of pigs was not influenced by the content of protein, total lactose, alpha-lactose hydrate, calcium, phosphorus, total ash or by the alkalinity of the ash in the samples of dried whey studied.

THE ISOLEUCINE REQUIREMENT OF SWINE AT TWO STAGES OF GROWTH. D. E. Becker, I. D. Smith, S. W. Terrill, A. H. Jensen and H. W. Norton, *University of Illinois.*

Three experiments were conducted with weanling pigs weighing 30–35 lb. to measure the isoleucine requirement and its relation to the dietary protein level. A synthetic diet containing soluble blood flour supplemented with methionine was used as an isoleucine-deficient diet and was calculated to contain 88% total digestible nutrients. Supplementary L-isoleucine was added as a 32% concentrate with D-alloisoleucine as the remainder. With a diet containing 13.35% protein the maximum rate and efficiency of gain were obtained with a minimum level of 0.46% L-isoleucine, equal to 3.4% of the dietary protein. On the other hand, with 26.7% protein the maximum rate and efficiency of gain occurred at a minimum level of 0.65% L-isoleucine equal to 2.4% of the dietary protein. The L-isoleucine needs in the high- and low-protein diets were 0.74 and 0.52% of the total digestible nutrients. Assuming a linear relationship between isoleucine need, expressed as percentage of the protein, and dietary protein, the isoleucine need within the protein range studied can be expressed by the equation $\hat{Y}=4.5-0.076X$, where $\hat{Y}$ is the isoleucine need and X is the percentage of dietary protein. The suckling pig weighing about 10 lb. and fed a similar diet containing 22% protein required a minimum of 0.76% L-isoleucine for maximum rate and efficiency of gain. The suckling pig need was equal to 3.5% of the dietary protein and 0.86% of the total digestible nutrients.

STUDIES IN RUMINANT NUTRITION. II. FURTHER STUDIES IN THE DEVELOPMENT OF A PURIFIED DIET FOR DAIRY CATTLE. J. H. Byers, J. R. Staubus and K. E. Gardner, *University of Illinois.*

Byers *et al.* in 1955 suggested that poor gains of dairy steers on a purified diet may have been due to the level of fiber in the ration. Further studies have shown that steers with a lower fiber ration but with urea as the sole nitrogen source after 4 weeks develop enlarged pasterns, swollen knees and hocks and posture difficulties. When a soybean product replaced urea as the nitrogen source on a protein equivalent basis, these symptoms did not develop and gains of 1.5 lb. per day were obtained. The diets consisted of 35% wood floc, 38% corn starch, 15% sugar, 4% mineral mix, 4% corn oil, vitamins A, D, E and K and either urea or a purified soybean product to equal a 12% protein ration. Digestion studies showed the digestibility of the dry matter of the diet containing urea as the sole nitrogen source to be 78.36%. When the urea was replaced with a soybean product as the sole nitrogen source the dry matter digestibility was 71.03%. The coefficient of digestibility of the nitrogen of the urea diet was 77.6% whereas that of the soybean-product diet was 72.4%. Average daily excretion in the urine of total nitrogen was almost twice as high on the urea diet as on the soybean product diet. Urea nitrogen excretion in the urine of the urea diet steer was more than twice as high as the soybean-product-fed steer. Ammonia nitrogen excretion in the urine of the urea-diet-fed steer was almost five times that of the soybean product fed steer.

THE VALUE OF HIGH-OIL CORN IN RATIONS FOR LAMBS. U. S. Garrigus and E. E. Hatfield, *University of Illinois.*

High-oil corn (containing approximately 8.0% ether extract) has been compared with regular corn (a mixture of the commonly used varieties) in creep-fattening rations of lambs for four years. The high-oil corn was substituted for the regular corn in the test ration. No caloric adjustments of the rations were made. Weight gains were the criteria for comparisons. *1953:* the ADG of 18 lambs on the basal (regular corn) ration and of 17 lambs on the high-oil corn rations were 0.45 and 0.46 respectivley. *1954:* the ADG of 22 lambs on the basal and of 22 lambs on the high-oil corn ration were 0.50 and 0.55 respectively. The difference was significant ($P<0.05$). *1955:* three lots of 23 lambs each were fed a basal, a high-oil corn ration, and a high-oil corn ration with an added emulsifier respectively. The ADG were 0.54, 0.65, and 0.62 respectively. The differences between the high-oil corn ration lots and the basal lot were significant ($P<0.01$ for lot 2 and $P<0.05$ for lot 3). *1956:* the ADG of 19 lambs on basal and 17 lambs on the high-oil corn creep rations were 0.42 and 0.44 respectively. These lambs were from ewes which received a corn silage ration during gestation and lactation. The ADG of 18 lambs on the basal and of 21 lambs on the high-oil corn creep were 0.34 and 0.38 respectively. The lambs were from ewes which received an oat silage ration during gestation and lactation. A nitrogen-balance study comparing high-oil corn rations with regular corn rations will be reported.

SOME FACTORS INFLUENCING THE LYSINE REQUIREMENTS OF RATS AND SWINE. H. D. Hutchinson, S. W. Terrill, A. H. Jensen, D. E. Becker and H. W. Norton, *University of Illinois.*

Experiments involving 190 rats and 114 pigs were conducted to determine the effects of four levels of protein, chlortetracycline at 120 p.p.m., level of feed intake and resulting growth rate, and age of animal on the lysine requirements. Growth, feed efficiency and in some cases N. balance were used as criteria of evaluation. Sesame oil meal was the chief protein source in the semi-purified diets used in all tests. Weanling pigs averaging 45 lb. in weight were individually fed a 11.69% protein ration for four weeks. Optimum gain and feed efficiency were realized when the lysine level was 0.52% of the ration. With a 14.25% protein ration containing 0.525% l-lysine supplementary levels of lysine gave no significant increase in growth rates. When this latter ration was supplemented with DL-lysine to provide levels of 0.625, 0.725, 0.825, 0.925 and 1.025% l-lysine and fed to 60 very young pigs (average initial weight 9.5 lb.) growth rate was significantly increased ($P<0.001$) and the calculated l-lysine requirement for the very young pig under these conditions is 0.935%. In studies with weanling rats N-balance was increased 34.8% ($P<0.001$) when the basal ration was supplemented with lysine. However, no significant interaction was obtained between lysine levels and chlortetracycline when the latter was added at the rate of 120 p.p.m. When lysine was the primary limiting factor in the basal ration neither the level of feed intake nor the consequent difference in growth rate influenced the lysine requirement of the rat. The lysine requirement of the weanling rat was determined using diets which contained 15, 20, 30, and 35% protein.

PANTOTHENIC ACID DEFICIENCY IN THE CALF. A. J. Sheppard and B. Connor Johnson, *University of Illinois.*

A total of 26 calves have been used in studies on the production of pantothenic acid deficiency in the calf. An improved synthetic milk diet was used. Normal

growth was produced when calcium pantothenate was included in the vitamin supplement. The major characteristics of the deficiency in the calf are, progressively: scouring; nasal discharge; weeping; scaly dermatitis, particularly about the eyes ("spectacle eye") and lower jaw; rough haircoat; loss of appetite, with resultant weight plateau and weight loss. Finally some calves developed incoordination of gait and then inability to stand. Histological examination revealed extensive edema in the muscle tissue, pneumonic changes in lung tissue, hemorrhages and demyelination of the spinal cord and sciatic nerve. Calves treated in time responded to calcium pantothenate therapy with an increase in appetite and weight gain and eventual disappearance of dermo and other symptoms.

THE FEEDING VALUE OF CORN SILAGE COMPARED WITH RYE SILAGE ENSILED IN TWO STAGES OF DEVELOPMENT FOR DAIRY HEIFERS. K. E. Harshbarger, K. A. Kendall and G. D. Rolleri, *University of Illinois.*

In a study with 3 groups of 5 dairy heifers in each, two lots of rye silage made when the rye was in the prebloom (group 3) and the early dough (group 1) stages of development, were compared with excellent quality corn silage (group 2) in a feeding trial for a period of 112 days. Average starting weights (lb.) of heifers by groups were: (1) 419; (2) 422; and (3) 418. Silage was fed ad libitum. A grain mixture was fed at the rate of 4 lb. per head daily for the first 50 days after which the level fed was reduced to 3 lb. The dry matter percentages of the silages as fed were: (1) 28.1; (2) 29.9; and (3) 19.5. Average total silage consumed, per animal, in pounds, was (1) 2342; (2) 2799; and (3) 3043. Average daily weight gains (lb.) per animal, by groups were :(1) 1.02; (2) 1.70; and (3) 1.21. Silage dry matter (lb.) consumed per pound of weight gain by groups was: (1) 5.78; (2) 4.57; and 4.53. Average total gains in weight (lb.) by groups were: (1) 114; (2) 191; and (3) 136.5. Groups 2 and 3 were continued on the silages for a total of 148 days. The average daily weight gains per animal by groups was: (2) 1.76 and (3) 1.25 whereas the total silage (lb.) per animal consumed was (2) 3997 and (3) 4310. Heart girth measurements and wither heights reflected differences as related to the body weights.

COMPARISON OF THREE METHODS OF GRINDING CORN FOR BEEF STEERS. F. C. Hinds, R. W. Kleis, W. W. Albert and A. L. Neumann, *University of Illinois.*

The development of automatic feed handling and processing systems has renewed interest in various methods of preparation of feed for cattle. Some feeders have felt that the type of grinder used in preparing ear corn or shelled corn has a significant effect upon the performance of cattle. These independent hand-feeding tests were made to compare the performance of yearling steers full fed corn processed by different types of grinders. Since study of method of preparation rather than fineness of grind was the objective, attempts were made to control fineness. A statistical analysis of the modulus of grind in each study indicated fineness of grind of the various comparisons were similar. In the 1953 study, ear corn ground to equal fineness in a hammermill and a burr mill was fed to two randomly selected lots of 10 steers each. In the 1954 study, ear corn ground to similar fineness by a hammermill, a burr mill, and a knife mill was used to finish three lots of 10 steers each. Shelled corn, used in 1955, was ground with a hammermill and burr mill and was fed to two lots of 8 steers each. A statistical analysis of the data showed that the amounts of grain consumed did not differ significantly in any of the comparisons. Likewise there were no significant differences in gains

between lots of cattle fed corn prepared with the different mills. While the cattle refused some of the large cob particles (0.8 lb. per steer daily) in the hammermill ground feed, this refusal did not affect total grain consumption nor increase costs of gains.

THE EFFECT OF TYPE OF PHOSPHORUS SUPPLEMENT AND FINENESS OF GRINDING LIMESTONE ON MINERAL CONSUMPTION BY BEEF CATTLE. J. L. Williamson, A. L. Neumann, W. W. Albert and C. B. Ammerman, *University of Illinois.*

Ad libitum phosphorus consumption by Hereford yearling steers and calves was used to test the palatability of different commercial phosphorus sources. Bone meal was most palatable when offered alone followed by soft phosphate (colloidal clay), and one sample of dicalcium phosphate. Another commercial sample of dicalcium phosphate, Curacao (imported raw rock phosphate), and two defluorinated products were less palatable. When equal mixtures of salt and these phosphorus sources were offered bone meal was again most palatable, but differences between the other phosphorus sources were less distinct than when they were offered alone. Eighty Hereford heifers (3 lots of fattening calves and 2 lots of wintering calves) were allowed to select and consume ad libitum limestone ground to three different degrees of fineness: fine, medium, and coarse. The limestone was offered alone, and in combination with salt and steamed bone meal. Each of the five lots of heifers consumed finely ground limestone at a considerably higher rate than medium or coarsely ground limestone when offered as either a 50–50 mixture with salt; a mixture of ⅓ limestone, ⅓ steamed bone meal and ⅓ salt; or as limestone alone. The heifers consumed averages of 63.46% more fine, and 8.14% more medium than coarsely ground limestone. Mixing ground limestone with salt in a 1:1 ratio resulted in decreases in limestone consumption of 47.69% for fine, 25.71% for medium, and 20.31% for coarsely ground limestone. Mixing one part each of ground limestone, steamed bone meal, and salt resulted in a decrease in limestone consumption of 31.31% for finely ground, but an increase in consumption of 13.71% for medium, and 14.06% for coarsely ground limestone.

FINISHING HORMONE-FED STEERS IN DRY LOT OR ON PASTURE FOLLOWING SELF-FEEDING ON LEGUME PASTURE. W. W. Albert and A. L. Neumann, *University of Illinois.*

Many cattlemen prefer to dry lot-finish cattle that have been fed grain on pasture before marketing. The belief has prevailed that dry lot finishing is necessary to maintain or increase intake of concentrates. Cattlemen have observed that a period of dry lot finishing improves the hair coat and hence improves the selling price of the cattle. Twenty-nine steers averaging 980 lb. that had been self-fed ground ear corn with and/or without stilbestrol for 126 days on legume pasture were randomly allotted into two groups. Each group was further subdivided into a stilbestrol and a nonstilbestrol supplemented lot. Such allotment permitted pooling of dry lot and pasture data so that within lot treatment was not a factor in the results. Concentrate intake was 6% lower in the pasture lot, and gains were 12% slower and 8% more costly than in the dry lot. The dry lot steers appeared higher finished and had glossier hair coats. An appraisal committee placed a 50-cent per hundredweight higher value on the dry lot-finished cattle. The pasture-finished cattle had a 2.92% shipping shrink compared with a 2.46% shrink for the dry lot cattle. Stilbestrol supplemented steers (7.5 mg. per steer daily) outgained the control steers (2.66 versus 2.36 lb. per day) for 126 days while full-fed on pasture. The nonstilbestrol steers gained faster (2.00 versus 1.87 lb. per day) during the 56-day finishing period.

THE VALUE OF ANTIBIOTICS IN GRAIN RATIONS FED TO BEEF CATTLE ON LUSH PASTURE, WITH HORMONE RELATIONSHIPS. D. L. Staheli, A. L. Neumann, C. R. Acord and W. W. Albert, *University of Illinois.*

In Experiment 1, three lots of 850 lb. steers were fed a 10:1 ground ear corn-protein supplement mixture for 63 days (the lush pasture season): lot 1, full-fed in dry lot plus 5 lb. alfalfa hay daily; lot 2, hand-fed the same concentrate mixture at the rate of 6 lb. daily on alfalfa-brome pasture; and lot 3, same as lot 2 except that each steer received 75 mg. of chlortetracycline per day. Half the steers in each lot were implanted at the start of the test wih 48 mg. of diethylstilbestrol. ADG were 2.74, 1.98, and 1.97 lb. respectively, indicating no beneficial response from chlortetracycline on a high-quality pasture ration. Pooling the data for comparison of control versus implanted steers on pasture shows ADG of 1.60 and 2.44 lb. respectively while comparable data for the dry lot steers are 2.71 and 2.78 lb. respectively. In Experiment 2, three lots of 580 lb. heifers were fed for 42 days on the above concentrate mixture: lot 1, full-fed in dry lot plus 5 lb. alfalfa hay daily; lot 2, self-fed the same concentrate mixture on spring oat pasture; and, lot 3, same as lot 2 except 75 mg. of oxytetracycline were fed per head daily. Half the heifers in each lot were implanted with 40 mg. of diethylstilbestrol at the start of the test. Daily concentrate consumpion was 15.0, 16.3, and 11.6 lb. respectively, and much more pasture was eaten by the antibiotic-fed heifers. ADG were 2.48, 2.58, and 1.87 lb. respectively, a significant decrease in the oxytetracycline lot. Implanted heifers gained 2.3 lb. daily on pasture compared with 2.15 lb. for controls. Both dry lot treatments produced gains of 2.47 lb. daily. Concentrates required per 100 lb. gain were 625.8, 648.6, and 778.3 lb. respectively.

A STUDY OF TRIMETHYLALKYLAMMONIUM STEARATE AND CHLORTETRACYCLINE SUPPLEMENTED RATIONS FOR FATTENING LAMBS. B. M. Shinn, J. E. Hill and E. R. Pharris, *Armour and Company.*

Studies were conducted with 345 southwestern, 80 lb. lambs, selected for uniformity, to evaluate the effects of trimethylalkylammonium stearate and chlortetracycline on growth. The lambs were randomly divided into 15 equal lots assigned to 5 treatment groups. The basal ration, ground and mixed, was fed to Group 1. Group 2 received the basal ration plus 10 mg. of chlortetracycline per pound of feed for the 54-day fattening period. Groups 3, 4 and 5 received the basal ration plus 50, 75 and 100 mg., respectively, of trimethylalkylammonium stearate per pound of feed. The results indicate that, under the conditions of this trial, trimethylalkylammonium stearate at 50 mg. per pound of feed and chlortetracycline at 10 mg. per pound of feed resulted in 17.5 and 15.8% greater daily gains and 11.6 and 7.8% improved feed efficiencies, respectively, over the basal group. Mortality, caused by enterotoxemia, was effectively controlled by all levels of trimethylalkylammonium stearate and by chlortetracycline when fed throughout the fattening period. Carcass yields and grades were not altered by the ration treatments.

STILBESTROL AND STILBESTROL OXYTETRACYCLINE COMBINATIONS FOR STEERS FATTENED ON CORN SILAGE. Max E. Smith, Harold E. Scheid and Logan T. Wilson, *Honeggers & Co., Inc.*

The effect of stilbestrol and stilbestrol-oxytetracycline (terramycin) combination upon rate of gain, feed efficiency, and carcass grade was tested on steer calves fed a fattening ration of corn silage and 3030 cattle supplement (30% crude protein and 30% molasses.) Three groups of steer calves, 10 per lot, averaging 475 lb.

were full fed corn silage twice daily, and 3 lb. daily of 3030 supplement. Lot 1 served as the control, lot 2 basal plus 5 mg. stilbestrol and lot 3 basal plus 5 mg. stilbestrol and 40 mg. oxytetracycline. After lots 2 and 3 averaged 600 lb., in body weight, the levels of stilbestrol and oxytetracycline were doubled to a daily intake of 10 mg. and 80 mg., respectively. Results in each lot in order named were: av. final weight, 953, 1019, and 1010 lb.; av. daily gain 2.34, 2.64, 2.63 lb.; av. daily feed of corn silage 40.0, 43.2, 43.0 lb.; feed per lb. of gain 18.4, 17.5, 17.5 lb.; dressing percentage 60, 59.5, 60.4; carcass grades 6 choice 4 good, 3 choice 7 good, 8 choice 2 good; feed cost per lb. of gain 13.7¢, 13.1¢, and 13.4¢. Feeding stilbestrol or a combination of stilbestrol and oxytetracycline caused a significant ($P<.05$) increase in daily gain and a 5% saving in feed. Cattle fed antibiotic with stilbestrol graded significantly higher ($P<.01$) than the groups fed stilbestrol alone or no stilbestrol. Evidently feeding an antibiotic will improve fat deposition and carcass grade. Carcass data show that cattle fed stilbestrol alone, shrank more in shipment and had a lower dressing percentage than the control or the oxytetracycline-stilbestrol group.

RELATIONSHIP OF PROTEIN, PRODUCTIVE ENERGY AND UNIDENTIFIED GROWTH FACTORS IN SWINE NUTRITION. J. H. Hare, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Inc.*

Rate of gain and feed efficiency of swine (corn-soy diet) were improved with increments of either protein or productive energy and were further improved by addition of a source of unidentified growth factors (UGF). With constant energy, average daily gain (ADG) and feed efficiency (FE) of baby pigs were 0.55 lb. and 2.16 lb. on 16% protein and 0.67 and 1.92 lb. on a 20% protein. With a fermentation source of UGF included, ADG and FE (in pounds) were 0.60 and 2.14 on 16% protein and 0.71 and 1.93 on 20% protein. In a second experiment, ADG and FE were 0.54 and 2.05 on 16% protein and 0.70 and 1.93 on 20% protein. With a fermentation source of UGF included, the ADG and FE were 0.55 and 2.25 on 16% protein and 0.73 and 1.91 on 20% protein. For the combinations of low protein-low energy, low protein-high energy, high protein-low energy and high protein-high energy, the ADGs were respectively 0.93, 0.87, 0.94, and 1.03 lb. When a UGF source was included, these values were 0.83, 0.95, 1.01, and 1.11. Feed efficiencies similarly improved. Data on growing-fattening pigs will also be reported. From these studies it appears that in practical swine rations there is a role for UGF sources which is independent of energy and protein levels.

THE COMPARATIVE EFFECT OF ORAL AND SUBCUTANEOUS IMPLANTATION OF DIETHYLSTILBESTROL FOR FATTENING STEERS ON DRY LOT AND PASTURE. W. M. Beeson, T. W. Perry, F. N. Andrews, W. H. Smith and Martin Stob, *Purdue University.*

Experiment 1—In dry lot, twelve groups of 6 steers each were full-fed on a basal ration of corn-and-cob meal, Supplement A, corn silage and minerals. The treatments and daily gains in pounds after 182 days were: Control, 2.29; 10 mg. stilbestrol orally, 2.62; 12 mg. stilbestrol implant, 2.44; 24 mg. implant, 2.45; 36 mg. implant, 2.75; 48 mg. implant, 2.64; 80 mg. chlortetracycline, 2.37; 10 mg. stilbestrol orally with 80 mg. chlortetracycline, 2.77; 12 mg. implant with 80 mg. chlortetracycline, 2.66; 24 mg. implant with 80 mg. chlortetracycline, 2.65; 36 mg. implant with 80 mg. chlortetracycline, 2.80; 48 mg. implant with 80 mg. chlortetracycline, 2.76. Feed efficiency was improved 10% for 36 mg. stilbestrol implant and 8.4% by feeding 10 mg. stilbestrol orally. Experiment 2—On legume pasture, 4 lots of 12 steers each were fed on a daily basal diet of ground ear corn 8 lb., Sup-

plement A 1.5 lb., and minerals free choice. The average daily gain and feed required per 100 lb. of gain to date (May 29-August 8, 1956—70 days) were respectively, in pounds: Control 2.20, 350; 10 mg. stilbestrol orally 2.08, 370; 24 mg. stilbestrol implant 2.49, 310; and 36 mg. stilbestrol implant 2.63, 293. The differences in daily gains between the control and the 24 or 36 mg. implanted steers were significant at the 5% and 1% levels respectively. There was no difference in the side effects between oral feeding and implanting in either experiment. Increased teat length was the only side reaction that could be detected when these data were summarized.

THE COMPARATIVE VALUE OF THE PHOSPHORUS IN PHOSPHORIC ACID, MONO- AND DICALCIUM PHOSPHATES, STEAMED BONE MEAL, CURACAO ISLAND PHOSPHATE, AND SOFT PHOSPHATE WITH COLLOIDAL CLAY FOR GROWING SWINE. C. E. Jordan, M. P. Plumlee and W. M. Beeson, *Purdue University*.

Six pigs 6 to 8 weeks of age were fed individually for 56 days *ad libitum* on each treatment on a semi-purified basal diet containing corn starch, cerelose and beef blood fibrin and fortified with pure vitamins, minerals and unidentified factors. The basal diet contained 0.035% phosphorus, 0.10% calcium and 18% crude protein. Each phosphorus supplement was added to the basal ration to provide a level of 0.30% phosphorus in the respective test rations. The calcium content was adjusted with calcium carbonate to 0.82% for Trial 1 and 0.65% for Trials 2 and 3. Blood inorganic phosphorus analyses were made on each pig every 14 days. In Trial 1 the average daily gains were: dicalcium phosphate, 1.41; monocalcium phosphate, 1.33; and "soft phosphate", 1.15 lb. The blood phosphorus values for the "soft phosphate" group were lower ($P<0.01$) than any of the other treatments. In Trial 2 the average daily gains were: dicalcium phosphate, 1.38; monocalcium phosphate, 1.36; bone meal, 1.37; Curacao, 1.24; "soft phosphate", 0.84 (lower, $P<0.01$, than any other group); and dicalcium phosphate plus fluorine (373 p.p.m. equal to the level in the "soft phasphate" group), 1.44 lb. Feed per unit gain was higher ($P<0.01$) in the "soft phosphate" group than any other group. Blood phosphorus values were lower ($P<0.01$) in both the "soft phosphate" and Curacao groups than the other treatments. Stiffness and weakness of the legs and back appeared earlier, more frequently and became more severe in the "soft phosphate" group. Data will be presented on the comparative value of phosphoric acid and dicalcium phosphate for swine.

SELF-FEEDING FREE CHOICE VS. SELF-FEEDING A COMPLETE MIXTURE FOR FATTENING STEERS. T. W. Perry, M. T. Mohler and W. M. Beeson, *Purdue University*.

The performance of fattening yearling steers in drylot self-fed the components of their ration on a cafeteria-style basis was compared with that of similar steers hand-fed in the conventional manner. The self-feeding of steers resulted in: (a) significantly increased rate of gain (2.70 lb. vs. 2.48 lb. per day); (b) greater consumption of Purdue Supplement A (5.43 lb. vs. 3.50 lb. per day); (c) twelve percent less TDN per 100 lb. gain; (d) less shrink in transit to market (4.4% vs. 5.2%); (e) slightly more than 1% greater dressing percent; and (f) increased liveweight selling price ($24.25 vs. $23.85 per cwt).

In a second experiment, hand-fed fattening cattle fed 2.0 lb. Supplement A with a full feed of corn and cobmeal gained as rapidly and as efficiently as those hand-fed 3.5 lb. of Supplement A. Self-fed cattle gained 10% more rapidly (2.58 vs. 2.35 lb. per day), dressed 2% higher and sold for slightly more than hand-fed cattle.

In a third experiment yearling steers were turned in to their respective lots in which their troughs were filled with a mixture of ground ear corn to Supplement A in the following ratios: 4 corn and cobmeal to 1 Supplement; 6 to 1; 8 to 1; 10 to 1; or 12 to 1. All lots of cattle gained satisfactorily on these self-fed rations which contained no roughage other than that contained in the cob-portion of ground ear corn. Cattle consuming the 6 to 1 ratio of ground ear corn to Supplement A gained most rapidly, while those consuming the 8 to 1 or 10 to 1 ratios required less feed per unit of gain.

EFFECT OF PROTEIN LEVEL UPON RESPONSE OF BEEF CATTLE TO OXYTETRACYCLINE AND STILBESTROL. W. M. Reynolds, W. C. Sherman, P. P. Appel and H. G. Luther, *Chas. Pfizer & Co., Inc.*

Protein was varied during a 182-day feeding trial with Hereford steers fed oxytetracycline and/or stilbestrol or implanted with stilbestrol. From 0 to 112 days these animals were on a high-roughage ration of ground corn cobs, free choice, plus 2 lb. corn and 2 lb. protein supplement daily which supplied adequate protein for the first 56 days. During the period 56 to 112 days, with an increased consumption of corn cobs, protein was diminished to a marginal level. For the last 70 days of the trial, the steers were on a full feed of corn and cob meal plus 2 lb. protein supplement daily which supplied adequate protein. Satisfactory growth and feed efficiency responses to stilbestrol and/or oxytetracycline were obtained in the initial period, but during the period of marginal protein intake growth was slow in these supplemented groups as it was in the controls. In the final period, with a full feed, there was a resumption of response to stilbestrol and oxytetracycline. These results indicate the importance of adequate protein for satisfactory growth response to estrogens and antibiotics.

UTILIZATION OF DIFFERENT FORMS OF VITAMIN A BY BEEF CATTLE. W. C. Sherman, W. M. Reynolds, G. O. Kuhn, E. A. White, C. K. Whitehair and H. G. Luther, *Chas. Pfizer & Co., Inc.*

Groups of Hereford steers were depleted of vitamin A by feeding a ration composed of ground corn cobs and a protein supplement containing no source of carotene or vitamin A. When blood plasma levels had declined to less than 10 mcg. per 100 ml. the cattle were dosed orally with different levels of vitamin A in oil, in aqueous emulsion, and in dry gelatin beadlets. The vitamin A response of the cattle was followed by determination of plasma vitamin A every few hours after the initial dose was administered. Liver biopsy samples were taken as a measure of vitamin A storage. In animals receiving the aqueous emulsion of vitamin A and the vitamin A in dry gelatin beadlets, substantial levels of vitamin A appeared in the blood within 12 hours after administration. In animals fed the oil solution of vitamin A there was a delay in the appearance of the vitamin in the blood and the blood uptake curve was depressed as compared with the curve obtained with the aqueous and dry forms of vitamin A. Rate of blood uptake correlated well with liver storage values.

THE EFFECTS OF DIET ON THE RUMEN EPITHELIUM AND PAPILLAE OF DAIRY CALVES. W. P. Flatt, R. G. Warner and C. H. Gripppin, *Cornell University.*

The extent of papillary growth and the percent epithelium of the anterior ventral rumen sac were used as criteria of rumen development in a series of experi-

ments involving 47 Holstein calves and 4 mature cows. Growth of the papillae of the rumen wall was evaluated using an arbitrary grading system and the percent epithelium was determined by removing a section of the anterior ventral rumen sac immediately following slaughter of the animal, separating the epithelial layer from the remainder of the tissue, drying, and weighing. The effects of radically different dietary treatments including mineralized milk, hay, dry calf starter, dry calf starter and hay, rumen liquor and rumen ingesta were studied. The calves were slaughtered at 15 weeks of age, after they had been on treatment for 12 weeks. Marked differences due to dietary treatment were noted, with the milk-fed calves showing the least rumen papillary development and the lowest percent epithelium. The papillae of the calves which had received solid materials such as grain, hay, or hay and grain were long and well developed. The greater proportion of ruminal epithelium of calves receiving solid feeds indicated that most of the development occurred in the epithelial layer. Slaughter studies with mature cows, veal calves and newborn calves also demonstrated an increase in percent epithelium with greater papillary development.

RESPONSE OF CALVES TO THE FEEDING OF ANIMAL DIASTASE AND PEPSIN. L. Ratcliff, N. L. Jacobson and D. V. Catron, *Iowa State College.*

Sixteen Holstein calves (8 males and 8 females) were divided into two comparable groups. All calves in group I received whole milk (for 7 weeks), starter and hay; half the calves of each sex received a gruel (finely ground dry feeds plus water) from the fourth week through the eleventh week. Calves in group II were fed similarly to those in group I except each calf received pepsin (1:3000 N.F.) and animal diastase (6 × U.S.P.) at the rate of 1% and 0.167%, respectively, of dry matter intake. The average gain per animal in group I for the 16-week period was 166 lb. as compared to 156 lb. per animal in group II, a difference which was not statistically significant. Furthermore, the general shapes of the two growth curves were similar. The average feed consumption in pounds per animal in groups I and II, respectively, were: milk, 342 and 337; gruel, 17 and 19; starter, 323 and 307; hay, 172 and 157. The average gain for calves receiving gruel was 169 lb. as compared to 153 lb. per animal for those receiving no gruel (difference not statistically significant). The average pounds of feed consumed by calves receiving no gruel and gruel, respectively, were: milk, 335 and 343; gruel, 0 and 36; starter, 343 and 288; hay, 163 and 167.

INFLUENCE OF STILBESTROL UPON DIGESTIBILITY AND NITROGEN RETENTION IN LAMBS USING LOW AND HIGH LEVEL PROTEIN RATIONS. Arthur Struempler and Wise Burroughs, *Iowa State College.*

Five digestibility and nitrogen retention trials were conducted with lambs involving three levels of dietary protein, three levels of stilbestrol administration and rations containing protein mixtures of varying amino acid content. Nitrogen retention was increased significantly by stilbestrol feeding in the higher protein rations (14 and 20%) the increase being about the same magnitude on a lamb-day basis. With the lower protein ration (8%) increased nitrogen retention was slight or failed to occur as a result of stilbestrol administration. Altering the amino acid contents of the ration also failed to influence this result. No significant difference was noted between stilbestrol additions of either 1.2 or 2.4 mg. per lamb per day. Dry matter and protein digestibility were unaffected by stilbestrol administration irrespective of its influence or lack of influence upon nitrogen retention.

THE VALIDITY OF THE ARTIFICIAL RUMEN TECHNIQUE IN MEASURING PHOSPHORUS AVAILABILITY TO CATTLE AND SHEEP. Arthur Raun, Russell Anderson, Edmund Cheng, W. H. Hale and Wise Burroughs, *Iowa State College*.

Phosphorus availability in cattle and sheep feeds can be determined rapidly and precisely with a minimum of expense employing a newly developed laboratory rumen technique. The advantages of this technique are obvious if the results obtained can be reliably applied directly to cattle and sheep. Experiments were accordingly carried out with these two species of livestock using three sources of phosphorus, namely dicalcium phosphate, colloidal clay, and phytate phosphorus as well as comparable laboratory rumen studies. The results obtained in the laboratory rumen showed the phosphorus in dicalcium phosphate to be the most available followed by phytate phosphorus with colloidal clay having the lowest availability. Weight gains in cattle and sheep using these same phosphorus sources correlated closely with the laboratory rumen results. Similar relationships were observed in blood inorganic phosphate in lamb experiments where the basal ration was extremely low in phosphorus prior to phosphorus supplementation. In a cattle experiment containing a basal ration relatively high in phosphorus, no differences were noted in blood inorganic phosphorus following phosphorus supplementation even though phosphorus supplemetnation resulted in marked liveweight gain stimulation. From these results it appears that the newly developed laboratory rumen technique for phosphorus availability is a valid method directly applicable to cattle and sheep nutrition.

SUPPLEMENTARY PLANE OF NUTRITION FOR SOWS FED CORN SILAGE. C. W. Johnson, V. C. Speer, G. C. Ashton and D. V. Catron, *Iowa Agricultural Experiment Station*.

Two supplementary planes of gestation supplement feeding (*Even*-fed and a *Low-High*-fed group), were tested on 52 sows and 60 gilts receiving 12 lb. each of corn silage daily. The Even group received a constant daily amount of a balanced 20% protein supplement from breeding to farrowing. The Low-High group was fed the same total amount of the same supplement but a large part of it was withheld until the last one-third of gestation. The gilts on both systems were fed slightly more than the sows. All sows and gilts were handled similarly prior to breeding. They were allotted at random at breeding time to the Even and Low-High feeding groups. The 29 sows in the Even group farrowed 11.4 pigs per litter with a birth weight of 2.9 lb. each; the 23 sows in the Low-High group farrowed 12.8 pigs per litter with a birth weight of 2.8 lb. each. The 30 gilts in the Even group farrowed 10.2 pigs per litter with a birth weight of 2.8 lb. each; the 30 gilts in the Low-High group farrowed 11.7 pigs per litter with a birth weight of 2.7 lb. each. The increase in pigs per litter of 1.4 for sows and 1.5 for gilts in the Low-High group was statistically significant ($P<.05$). There was no statistical difference between treatments in the pigs classified strong, medium, weak or dead. Of the 112 sows and gilts only 4 farrowed a litter of less than 8 pigs.

VITAMIN A REQUIREMENTS OF THE BABY PIG. D. L. Frape, C. H. Liu, R. S. Allen, G. C. Ashton and D. V. Catron, *Iowa Agricultural Experiment Station*.

Eight experiments, involving 150 pigs, were carried out as preliminaries to the two involving 116 pigs, the results of which are presented here. In determining the vitamin A requirements of the pigs up to eight weeks of age several methods were evaluated. These methods indicate the different relationships existing between the

level of vitamin A intake and the criterion under investigation, and the widely varying requirements of different tissues. The criteria included; (1) blood plasma and liver (biopsy by laparotomy) vitamin A analyses; (2) cerebro spinal fluid pressure; (3) growth rate; (4) feed efficiency; (5) Sulphur^{35} metabolism, histological and gross examination of various tissues; and (6) visible clinical symptoms. The pigs were from sows maintained throughout gestation on rations deficient in Vitamin A. A synthetic stabilized form of vitamin A was fed to the young pigs. Trends shown in earlier experiments, in which several pigs were lost, were borne out by the results of these later experiments. Statistical analysis of the data from these showed significant (P 0.05 or less) regressions of blood levels, cerebro spinal fluid pressure, weight gain, and feed per lb. gain, on vitamin A intake. The blood level approached a plateau above 800 I.U. per lb. of feed, at which level a minimum liver storage occurred. Cerebro spinal fluid pressure reached accepted levels in the same range. About 100 I.U. were adequate for maximum weight gain. The feed efficiency followed a quadratic trend with a maximum efficiency at 55 I.U. per lb. of ration. Radio autographs of the sulphur studies will be presented.

SUPPLEMENTATION OF BABY PIG DIETS WITH ENZYMES. R. O. Baker, C. J. Lewis, R. W. Wilbur, P. A. Hartman, V. C. Speer, G. C. Ashton and D. V. Catron, *Iowa Agricultural Experiment Station.*

Experimental evidence indicates that the baby pig is deficient in certain digestive enzymes up to about 5 weeks of age. This has been substantiated by assays of the digestive enzyme secretory glands and by feeding tests. Research at this Station has approached this problem by; (1) supplementation of baby pig diets with enzymes, (2) assay of the baby pigs' digestive enzyme secretory glands and (3) feeding of hydrolysates of soya protein. Proteolytic enzymes have been fed at various levels to 895 pigs in 13 experiments. Animal, plant, fungal and bacterial enzymes have been used in this research. The response of the baby pig gains and feed efficiency has been quite variable to enzyme supplementation. Early studies indicated that pepsin gave the greatest increase in gain and feed efficiency. Enzyme supplementation increased the 1–5 week gains from −8 to +40%. The feed saving during this period ranged from −10 to +18%. To date the enzyme which seems to give the best response is pepsin (1:300) added at 0.25% of the diet. The two major factors which seem to govern the baby pig response to enzyme supplementation are; (1) age of pigs and (2) rate of food passage. Based on the presence of digestive enzyme in secretory glands, the younger the pig, the greater should be his response to enzyme supplementation. Also, the faster the food passes through the digestive tract the greater the response. Feeding pepsin in the presence of a cathartic, cascara, increased gains and feed efficiency by 19 and 9%, respectively. This is a fundamental bench mark which will influence the formulation of the baby pigs rations and the management of the baby pig.

LACTIC ACID AS AN INTERMEDIATE PRODUCT FROM DIFFERENT SUGARS FERMENTED BY RUMEN MICROORGANISMS. Edmund Cheng, *Iowa State College.*

It is well known that rumen microorganisms in cattle and sheep ferment various sugars rapidly with the eventual production of volatile fatty acids as end products. However, the intermediate products of sugar fermentation by rumen microorganisms are not well known and they at times may exert special nutritional influences. The accumulation of lactic acid in the rumen as a result of excessive feeding of grain to sheep has been reported by Hungate *et al.* Doetsch *et al.* failed to detect the presence of lactic acid upon dissimilation of several sugars by

washed suspension of rumen microorganisms. In the present investigation, it has been shown that sugars such as glucose, maltose, lactose, levulose, galactose, cellobiose, raffinose, mannose as well as starch and dextrin are readily dissimilated when they are incubated with suspensions of rumen microorganisms resulting in the production of lactic acid as an intermediate product. During the course of fermentation, there was an increase of lactic acid concurrent with the disappearance of sugars. The lactic acid formed was converted into volatile fatty acids upon further incubation with the suspension of rumen microorganisms. Trehalose was fermented at a slower rate. Only slight fermentation occurred with arabinose, rhamnose and ribose. Sugars such as turanose and sorbose were not fermented at all even after prolonged incubation with rumen microorganisms.

EFFECT OF CESIUM, LITHIUM, AND RUBIDIUM ON CELLULOSE DIGESTION BY RUMEN MICROORGANISM. Farris Hubbert, Jr., Edmund Cheng and Wise Burroughs, *Iowa State College.*

Minerals present in cattle and sheep feeds, such as alfalfa ash, exert strong influences upon rumen microorganism with respect to cellulose digestion and roughage utilization. Often times attempts to formulate mineral mixtures of known chemical composition patterned after mineral requirements of rumen microorganisms have failed to be as effective as alfalfa ash in bringing about maximum cellulose digestion. Cesium, lithium, and rubidium were, therefore, investigated since they are sometimes present in ruminant feeds and since their chemical properties resemble two other alkali metals, namely sodium and potassium which are known to exert substantial influences upon rumen microorganisms. An artificial rumen technique was employed using washed cell suspensions and a basal medium free from potassium or sodium. Rubidium was found to be effective in replacing a large part of the potassium required by rumen microorganisms for maximum cellulose digestion. Lithium and cesium were ineffective in this respect. Neither rubidium, cesium nor lithium was effective in stimulating greater cellulose digestion when ample potassium and sodium were present in the medium. The substitution influence of rubidium for potassium therefore appears unlike the relationship between sodium and potassium in that an addition of sodium appears to stimulate cellulose digestion in the presence of ample potassium.

THE EFFECT OF SUPPLEMENTARY DIETARY CHOLINE ON THE DISTRIBUTION IN YOUNG DAIRY CALVES OF ORALLY ADMINISTERED P^{32}. R. S. Allen, N. L. Jacobson and Vivian L. Neseth, *Iowa State College.*

Four male dairy calves (2 Holsteins, 2 Brown Swiss) ranging from 20 to 27 days of age were assigned to two comparable groups (one serving as control, the other receiving 1 gm. supplementary choline chloride per feeding). The diet consisted of reconstituted skimmilk with 3% lard, the mixture being homogenized at 3000 lb. pressure. Vitamin A was added at feeding time. Radioactive phosphorus ($H_3P^{32}O_4$) was administered as a single dose either by capsule or in the milk at the rate of 0.04 mc. per lb. body weight. Blood samples were taken at frequent intervals during the first day and then at 12-hour intervals until the calves were sacrificed after 4 days, at which time samples of various organs and tissues were collected. Choline had no apparent effect on the rate of absorption of P^{32}; on the level of radioactive blood plasma phospholipids; on the level of P^{32} in various tissues, intestinal contents, and bile; and on radioactive phospholipids in liver, heart, kidney, and spleen. Maximum blood levels of acid-soluble P^{32} were observed at 3 to 5 hours after the tracer was fed, whereas the tagged blood plasma phospholipid levels were greatest at 12 hours. The specific activity of P^{32} in the intestinal contents was greatest in the duodenum and least in the colon. The organ lipid P^{32}

values were greatest for liver, followed in turn by kidney, spleen, and heart. The tissues with specific activity of total P^{32} exceeding 0.03 included liver, kidney, duodenum, lymph nodes, cecum, ilium, bile, and bone epiphysis.

THE ALLEVIATION OF DIETARY FAT INHIBITION OF PROTEIN AND CELLULOSE DIGESTION IN SHEEP. R. W. Rhodes, F. H. Baker and R. B. Grainger, *University of Kentucky.*

Six groups of wethers (4 per group) were used in each of 4 metabolism trials. The feeding regime included distilled water and a semi-purified basal ration composed of cottonseed hulls (CSH), Drackett protein, urea, corn starch, corn syrup, iodized salt, di-calcium phosphate, magnesium sulfate, sulfur, and vitamins A and D. In all trials the digestibility of protein and cellulose of rations containing from 65 to 80% CSH was significantly decreased by replacing corn syrup with 1.8, 3.0, and 4.2% corn oil (CO). Nitrogen retention paralleled protein digestibility. The depression of crude protein digestibility was not signficantly different between rations which contained only preformed protein and those which contained 1.2% urea. This depression of protein digestibility was not improved by substitution of 16.8% distillers dried solubles (DDS) into the rations. The depression of cellulose digestibility was completely reversed by the DDS. In Trial IV with 78% CSH in the rations, the 6 treatments and the digestion coefficients for cellulose and protein respectively were: Basal, 56.4, 68.9; 3% CO, 53.1, 60.3; 3% CO plus 30 gm. alfalfa ash per wether per day, 59.3, 70.3; 3% CO plus 16.8% DDS, 52.1, 70.4; 3% CO plus 10 gm. DDS ash per wether per day, 56.2, 62.6; 3% CO plus 8.4% DDS, 53.4, 65.9. Thus certain factors important for ruminant digestion have been demonstrated. The factor(s) contained in the DDS ash and alfalfa ash function in ruminant digestion of protein. The organic factor(s) present in distillers dried solubles and the factor(s) in alfalfa ash function in cellulose digestion in the rumen.

THE CELLULOLYTIC INTERRELATIONSHIPS OF DIETARY FAT, CARBOHYDRATES AND MINERALS IN SHEEP METABOLISM STUDIES. C. E. Summers, F. H. Baker and R. B. Grainger, *University of Kentucky.*

Six groups of wethers (4 per group) were used in each of two metabolism trials. The feeding regime included distilled water and a semi-purified basal ration composed of corncobs, Drackett protein, urea, corn starch, corn syrup, iodized salt, di-calcium phosphate, magnesium sulfate, sulfur and vitamins A and D. In Trial I a decrease in the corncob content of a ration from 80 to 65% by corn starch replacement significantly reduced the digestibility of cellulose from 74.2 to 68.4%. Alfalfa ash (30 gm. per wether per day) completely alleviated the effect of the supplemental corn starch but had no effect on the digestibility of the 80% corncob ration. Corn oil (3%) added with alfalfa ash did not affect digestibility of the 80 or 65% corncob rations. Nitrogen retention was not affected by treatment. In Trial II all rations contained 65% corncobs. Alfalfa ash significantly improved cellulose digestibility and nitrogen retention. Corn oil (2%) significantly depressed the digestibility of cellulose and protein; these depressions were completely reversed and nitrogen retention was significantly improved by adding alfalfa ash with the corn oil. The depression of cellulose digestibility due to corn oil was completely reversed, but that of protein digestibility was unaffected by substitution of distillers dried solubles (16.8%) into the ration. The presence of a cellulolytic factors(s) in distillers dried solubles has been demonstrated. The rumen microbial requirements for an inorganic element(s) present in alfalfa ash appear to be increased by fat (corn oil) and/or carbohydrate (corn starch) supplementation of sheep rations.

THE RELATIONSHIP OF FEED INTAKE AND LENGTH OF COLLECTION PERIOD TO APPARENT DIGESTIBILITY OF A SELF-FED LAMB RATION. Nelson Gay, R. B. Grainger and F. H. Baker, *University of Kentucky*.

Forty-two cross-bred lambs were self-fed a pelleted ration composed of corncobs, 50.0; corn, 26.9; soybean oil meal, 15.0; hydrol, 7.0; $CaCO_3$, 0.42 and NaCl, 0.67%. Four pounds chromic oxide were added per ton of ration. After a 21-day preliminary period the lambs were individually bagged for seven consecutive days. Individual 3- and 7-day fecal composites were analyzed for chromic oxide to obtain individual feed intake. The mean daily intake, body weight and dry matter digestibility (DMD) were 2.95±0.69 lb., 70.0±10.6 lb. and 59.6±5.97% respectively. The R for daily feed intake, body weight and DMD was 0.15 for the 7-day collection period. Partial standard regression coefficients for body weight to DMD with daily intake constant and daily intake to DMD with body weight constant were 0.021 and —0.196 respectively. The regression coefficients for body weight to DMD, daily intake to DMD and body weight to daily intake were 0.06, 1.17 and 0.05 ($P<.01$) respectively. Analysis of variance comparing the DMD of the 3- and 7-day collection periods for 42 individuals approached significance ($P<0.05$). The mean DMD for the 3- and 7-day collection periods was 58.6±7.30 and 59.6±5.97. Selection of 20 individuals was made by a table of random numbers for the 3-day collection period and 20 individuals for the 7-day collection period. Analysis of variance comparing the DMD of lambs of 3- and 7-day collections groups showed a significant difference ($P<0.05$). The mean dry matter digestibility for the 3- and 7-day collection groups was 56.0±7.9 and 61.3±5.9.

COMPOSITION AND DIGESTION COEFFICIENT OF DRIED POTATO PULP; ITS USE IN STEER FATTENING RATIONS AND QUALITY OF THE CARCASSES PRODUCED. H. H. Brugman and H. C. Dickey, *University of Maine*.

Twenty-four steers were divided into 4 groups of 6 steers each and fed respectively corn, L.O.M. and hay; corn, L.O.M., hay and silage; dried potato pulp, L.O.M. and hay; dried potato pulp, corn, L.O.M. and hay. Gains, feed consumption, feed costs per pound of gain and carcass grades were established. Steers fed dried potato pulp made the cheapest gains, and the fat of the carcasses was whiter than that of the corn fed group. Carcass grades were U.S. Good to Choice as compared to U.S. Good to Standard on the corn fed group. Both the chemical composition and the digestion coefficient of dried potato pulp approach that of U.S. No. 2 corn.

TRACER STUDIES OF VOLATILE FATTY ACID PRODUCTION BY RUMEN BACTERIA. E. C. Leffel, S. Lakshmanan, W. H. Brown and J. C. Shaw, *University of Maryland*.

In a study of the effect of dietary regime upon the metabolic behavior of rumen bacteria, nine cows were placed on high concentrate-low roughage rations. Washed cell suspensions of rumen bacteria from each cow were prepared and incubated with uniformly labeled glucose and carboxyl-labeled acetate. The dissimilation of these substrates was followed by determining the amounts and specific activities of the volatile fatty acids produced. Incubation of washed cell suspensions under hydrogen for two hours before the addition of a radioactive substrate, did not appreciably affect the quantities or the molar ratios of the fatty acids formed. The ratios of the specific activities were also similar to those from washed cell suspensions that were not incubated under hydrogen. Since incubation

under hydrogen reduces volatile fatty acids from endogenous sources, it is a technique worth using routinely. One of the experimental cows bloated twice during the experiment. There was no significant difference in the manner of dissimilation of glucose or of acetate by rumen bacteria isolated during bloat, as compared with dissimilation studies on samples of rumen bacteria from the other cows. Data on the dissimilation of radioactive glucose and acetate by rumen bacteria of cows on a high concentrate-low roughage diet will be compared with the dissimilation of the same substrates by rumen bacteria from cows on normal herd rations.

EFFECTS ON BEEF CATTLE OF LOW PROTEIN AND ENERGY ALLOWANCES. C. F. Winchester, R. L. Hiner and V. C. Scarborough, APHRB, ARS, U. S. D.A.

Eight rations ranging from a caloric maintenance ration that was only 2.5% digestible protein (ration 1) to rations liberally supplied with protein and energy were fed to identical twin beef calves between the ages of 6 and 12 months. During restriction, animals on ration 1 lost weight while those on the other rations made gains that ranged from slight increases to 1.9 lb. a day depending on the quality of the rations and the amounts fed. Slaughter of each retarded animal was delayed until its degree of fatness approximated the final condition of its cotwin; slaughter weights of cotwins were similar. In spite of the drastic treatments given some animals, efficiency of feed utilization and carcass and meat quality of cotwins, with a possible exception, were similar. The exception consisted of a lower degree of desirability of fat of two of the animals fed ration 1 as compared with the fat of their cotwins. Within one of the pairs this was likewise true of the lean meat while within the other pair the situation was reversed. When energy intake was held near maintenance, changes in bodyweight were positively correlated with level of protein intake. The trials were begun with 12 pairs of twins of which one member of each of 2 pairs died before completion of the experiment.

CALCIUM AND ZINC IN PARAKERATOSIS OF SWINE. R. W. Luecke, J. A. Hoefer, W. S. Brammell and D. A. Schmidt, *Michigan State University*.

In a trial involving 6 lots of 10 pigs each the feeding of a ration containing 0.51% Ca and 0.61% P resulted in depressed growth and a 40% incidence of parakeratosis. In addition, rations containing 1.21% Ca and 1.90% Ca both with 0.61% P resulted in severely depressed growth and a 100% incidence of parakeratosis. In all cases the feeding of the same rations containing supplemental zinc (as zinc carbonate) markedly increased growth rate, improved feed efficiency and completely prevented symptoms of parakeratosis. All cases of parakeratosis were alleviated by zinc therapy. Preliminary studies indicated that dietary zinc increased serum alkaline phosphatase activity.

THE EFFECT OF VARIOUS ENZYMES ON THE GROWTH RATE OF DAIRY CALVES FED ON ALL VEGETABLE PROTEIN MILK REPLACER. G. F. Fries, C. A. Lassiter, C. F. Huffman, J. A. Williams and C. W. Duncan, *Michigan State University*.

Thirty two-day old Holstein calves were used in an experiment to determine the effect of subjecting a vegetable milk replacer to various enzymatic treatments. The composition of the milk replacer was 47.1 lb. corn, 32.5 lb. soy flour, 10.0 lb. corn distillers solubles, 5.0 lb. whey, 1.5 lb. bone meal, 0.5 lb. salt, 2.8 lb. Aurofac 2A, and 34 gm. vitamin and mineral mix. The treatments were: no treatment (C), predigested with malt diastase (D), predigested with papain (P), predigested with

a combination of the two enzymes (DP), and predigested with rumen juice (R). Each calf received 56 lb. of milk through the 20th day, 30.5 lb. treated milk replacer through the 40th day, and untreated milk replacer in dry form *ad libitum* through the 60th day. Average daily gains at 40 days were 0.38, 0.47, 0.10, 0.35 and 0.49 lb. and at 60 days were 0.65, 0.99, 0.59, 0.73 and 0.80 lb. for Groups C, D, P, DP and R respectively. Dry milk replacer consumption at 40 days was 34.0, 31.5, 18.0, 19.0 and 31.0 lb. and at 60 days was 90.8, 107.7, 68.1, 85.5 and 102.3 lb. for the five groups, respectively. The differences in gain and milk replacer consumption at both 40 and 60 days approached significance at the 5% level. Two calves from group P and one from group DP died shortly after 40 days of age. At necropsy the adrenal cortex of all three calves showed hemorrhage and/or necrosis. Mild hyperemia and some hemorrhages were noted in the alimentary tract.

THE PYRIDOXINE REQUIREMENT OF THE BABY PIG. E. R. Miller, D. A. Schmidt, J. A. Hoefer and R. W. Luecke, *Michigan State University*.

Eighty-nine baby pigs receiving a synthetic milk diet were used in four trials to determine their pyridoxine requirement. Levels of pyridoxine supplementation constituting 0, 0.5, 0.75, 1.0 and 2.0 mg. per kilogram of dietary solids were used. An analysis of the growth and feed consumption data indicates that the pyridoxine requirement of the baby pigs does not exceed 0.5 mg. per kilogram of dietary solids. However, data obtained on blood hemoglobin, red blood cell count, lymphocyte population and urine xanthurenic acid excretion are presented which indicate that the minimum requirement, when a more nearly total consideration of the pig's well-being is recognized, is not less than 0.75 mg. of pyridoxine per kilogram of solids. Classical deficiency symptoms were observed in those pigs receiving no pyridoxine. The performance of pair fed controls indicated that the reduced blood hemoglobin level, red blood cell count and lymphocyte population and the increased urine xanthurenic acid concentration found in deficient pigs were due specifically to a lack of pyridoxine and not an effect of the resulting inanition. Therapeutically treated, pyridoxine deficient pigs recovered rapidly.

THE RELATIONSHIP OF DIETARY CALCIUM TO ZINC METABOLISM IN PIGS. H. W. Newland, D. E. Ullrey, J. A. Hoefer and R. W. Luecke, *Michigan State University*.

Two experiments were conducted with weanling pigs fed rations of natural feed-stuffs. The treatments were as follows: Lot I, 0.64% Ca, 30 p.p.m. Zn; Lot II, 1.19% Ca, 33 p.p.m. Zn; Lot III, 1.23% Ca, 94 p.p.m. Zn. Three replications of three pigs each were used in each experiment. The feed intake of each trio was regulated by the pig consuming the least amount (the Lot II pig). Although energy intake was approximately equal, the pigs on the high-calcium, low-zinc diet (Lot II) made slower daily gains than Lots I and III, and consistently showed symptoms of parakeratosis. Except for one pig, in Lot I, there was no evidence of dermatosis in the other lots. In the first experiment growth and skin pathology were the only data collected. In the second experiment endogenous fecal zinc was determined by the isotope dilution technique. After one week on the experimental rations Zn^{65} was administered intravenously and the pigs were placed in metabolism units. Seven days postinjection the specific activities of the blood and feces were approximately parallel and the next five days were used for endogenous zinc determinations. Expressed as a percent of the total fecal zinc, the average daily excretion of endogenous zinc was significantly greater from the Lot II pigs. The daily excretion of endogenous zinc averaged 0.74 mg. daily in Lot I as compared to 1.01 and 1.22 mg. daily for Lots II and III, respectively. The pigs in Lot II also

showed a significantly higher daily fecal excretion of Zn^{65} and higher specific activities of both blood and feces as compared to Lots I and III. Lot II pigs had a significantly higher specific activity of the liver.

LAMB RESPONSE TO DICYANDIAMIDE. R. M. Jordan and H. G. Croom, *University of Minnesota.*

Dicyandiamide as a partial source of nitrogen in lamb fattening rations was studied. Four lots of ten western lambs each were full fed a basal ration of shelled corn, corn silage and mineral. The following protein supplements were fed daily per lamb: Lots 1 and 2, 0.3 lb. of solvent extracted soybean oil meal, (46.8% crude protein); Lots 3 and 4, 0.3 lb. of protein supplement consisting of 10% dicyandiamide and 90% ground corn, (49.0% crude protein equivalent). This mix was bitter tasting and the lambs refused it in any feed with which it was mixed. At the end of seven days the supplement mix was changed so as to contain 2.75% dicyandiamide, 87.25% ground corn and 10% soybean oil meal (23% crude protein equivalent). Iso-nitrogenous intake was obtained by feeding .6 lb. of this supplement daily per lamb. At this level the total grain ration contained less than 1% dicyandiamide. In spite of this it was 31 days before the lambs became entirely accustomed to it. Feeding this level of dicyandiamide to the control lambs for 1 day caused them to go off feed. Concentrate intake (grain and protein supplement) was approximately the same in the control lots and the dicyandiamide lots. However, silage intake was reduced .10 to .25 lb. daily per lamb. Average daily gain per lamb during the entire trial was .371, .333, .268 and .304 lb. in lots 1, 2, 3, and 4 respectively. The greatest difference in average daily gain occurred during the first 56 days of the trial. The product does not lend itself to lamb fattening rations when mixed as described in this trial.

OATS AS A CATTLE FATTENING FEED. H. B. Geurin, J. C. Thompson, H. L. Wilcke and R. M. Bethke, *Ralston Purina Company.*

Past experimental results show that cattle do not fatten satisfactorily on an oats-roughage ration. Thus recommendations have been to eliminate or restrict oats for finishing cattle irrespective of the price relationship to other grains. The concept of using oats as both grain and roughage was tried in a comparison with rolled barley and limited alfalfa hay. Twenty steers that had been fed on a grass silage growing ration for 140 days were equally divided in two lots and fed either crimped oats and a 32% protein supplement fortified with vitamin A and trace minerals or rolled barley, limited alfalfa hay and a 32% protein supplement. The cattle were sold in the choice grade after 91 days on test with the daily gains, total feed per 100 lb. gain, shipping shrink, live selling price, dressing percent and carcass grade for barley and oats fed steers respectively as follows: 2.50, 2.31; 850, 855; 2.8, 4.0; $19.75, $19.50; 62.4, 59.9; Choice, Low Choice. The steers fattened on oats returned $1.04 more profit per steer. Further tests with oats as the only source of grain and roughage in comparison with either ground ear corn or oats and ground shelled corn combination are in progress.

THE INFLUENCE OF TIME OF FEEDING OF ROUGHAGE AND CONCENTRATE ON THE UTILIZATION OF RATIONS BY WETHERS. W. H. Pfander and C. W. Gehrke, *University of Missouri.*

Digestion trials were run to determine the effect of time of feeding of hay and concentrate on the utilization of rations. Twelve mature wethers were fed 800 gm. of U.S. No. 4 Timothy hay or U.S. No. 3 Alfalfa hay and 212 gm. of con-

centrate mixture containing soybean meal, corn, urea, $CaHPO_4$, trace mineralized salt, and Vitamin A & D. In some trials 70 gm. blackstrap molasses were included. In each trial 14 day preliminary and seven day total collection periods were used. During a two year period each sheep received the following combinations: A: one-half of complete ration at 7:00 a.m. and 5:00 p.m., B: Concentrate at 7:00 a.m. and 2:30 p.m.; hay at 9:30 a.m. and 5:00 p.m., C: Hay at 7:00 a.m. and 2:30 p.m. concentrate at 9:30 and 5:00 p.m., D: Hay and concentrate at 12 hour intervals, E, F, G, H: As ABCD with molasses in concentrate, IJKL: As ABCD with molasses on hay. Each roughage was fed with each combination of concentrate and molasses. As compared to the utilization of the complete ration, highly significant decreases in digestibility were found during the periods when the components of the ration were fed separately. For example co-efficients of digestibility obtained on the complete ration with molasses were 77.9, 65.2, and 68.8 for nitrogen, cellulose and organic matter, respectively. When hay and molasses were fed 2.5 hours after the grain, the co-efficients fell to 71.2, 58.2 and 62.0. Similar differences in ruminal volatile fatty acids were found. The implications of these findings with respect to current feeding practices will be discussed. Contribution from the Missouri Agri. Experiment Station, Journal Series No. 1661. Approved by Director.

THE EFFECTS OF SOURCES OF VITAMIN A AND YEAST UPON UTILIZATION OF VITAMIN A BY BEEF STEERS. D. P. Heaney and O. O. Thomas, *Montana Agricultural Experiment Station.*

Sixteen Hereford steers depleted in vitamin A, were supplemented by capsule with 50,000 I. U. of vitamin A per steer daily for five or ten days, or 100,000 I.U. daily for ten days. The two types of concentrated vitamin A supplements studied were a corn-oil suspension of vitamin A and vitamin A palmitate in gelatin. Yeast was added to the depletion rations of half the steers. Changes in blood plasma and liver vitamin A levels were used to determine utilization of vitamin A. There were no consistent differences in the effects of the two types of vitamin A supplements used on plasma vitamin A content or vitamin A storage in the liver. The depletion of vitamin A from the liver was faster when the steers received the corn-oil suspension of vitamin A. The addition of yeast to the ration had no apparent effect upon plasma vitamin A values, but did tend to induce higher liver stores of vitamin A with slower subsequent depletion of liver stores. The level of 50,000 I.U. of vitamin A per steer daily for five days was insufficient to initiate liver storage. When increased to a ten-day supplemental period, 50,000 I.U. did initiate liver storage and 100,000 I.U. per steer daily provided substantial liver storage. After vitamin A supplementation stopped, plasma and liver vitamin A content decreased rapidly at first but tended to level off as the plasma and vitamin A values decreased.

EFFECT OF FEEDING STILBESTROL TO STEERS WINTERED ON THE RANGE UPON SUBSEQUENT SUMMER GAINS. O. O. Thomas, R. R. Woodward, J. R. Quesenberry and F. S. Willson, *Montana Agricultural Experiment Station and U. S. Range Livestock Experiment Station.*

One hundred yearling steers were fed 2 lb. daily of a 20% protein pellet as a supplement on native range from January 3 to April 24, 1956, inclusive. One group of 50 head was fed a control pellet and the other group the same pellet to which was added 5 mg. of stilbestrol per pound. At the conclusion of this winter phase, each group was redivided with 25 steers per treatment making up two new groups of 50 head that were grazed on crested wheatgrass (*Agropyron cristatum*)

until July 6. Two pounds daily of a lower protein pellet (14%) was fed as a supplement during the summer phase with stilbestrol again included at a level of 5 mg. per pound. Pasture differences were minimized by rotation at 28-day intervals. The average total gain for the stilbestrol fed steers during the winter phase was 127 and 115 lb. for the controls. This difference was statistically non-significant. Steers fed stilbestrol continuously through both the summer and winter phases and for the summer phase only made significantly greater gains for the total period than did control steers. Gain differences between steers fed stilbestrol continuously as opposed to winter feeding only were non-significant indicating some carryover effect. Total gains for both phases were 309 lb. for steers fed stilbestrol continuously, 311 lb. for steers fed stilbestrol during the summer only, 298 lb. for steers fed stilbestrol during the winter only, and 275 lb. for steers fed as controls.

"THE EFFECT OF CALCIUM CHLORIDE ON RUMINANT RATIONS CONTAINING UREA AS THE PRINCIPAL NITROGEN SOURCE." Janet L. C. Rapp and Phillip C. Anderson, *Feed Service Corporation.*

Eight hereford heifers were fed free choice ground corn cobs and a liquid supplement containing molasses, urea, phosphoric acid, ethanol and trace minerals. Various amounts of calcium chloride were dissolved in the liquid supplement. Daily intake of the liquid supplement was sharply decreased. Daily intake of the corn cobs was only slightly depressed. The addition of sodium hydroxide in equinormal amounts in respect to the calcium chloride restored the daily intake to normal; thus, demonstrating that the chloride and sodium requirements of ruminants, as determined by palatability factors, are not independent.

PROTEIN SUPPLEMENTS FOR WINTERING BEEF CATTLE. Verle R. Bohman and Clark Torell, *University of Nevada.*

Wintering beef calves fed hay harvested at an early stage of maturity gained significantly more than animals fed hay harvested later. During the following summer, the retarded cattle accelerated their growth rate and were as heavy the following fall as the non-restricted group. The feeding of protein supplements tended to mask the differences in nutritive value of hays harvested at different stages of maturity. Cattle that had been individually-fed during the winter gained faster the following summer than similar cattle group-fed during the winter. Protein supplements markedly increased the winter gains of the beef calves. However, the subsequent summer gains depended upon the type of protein supplement fed the preceding winter. Alfalfa stimulated the greatest summer gains; cottonseed meal the least; and the control animals without supplements were intermediate. With the exception of the alfalfa treatments, there was less difference in total gains between the control animals and the supplemented cattle at the end of the summer grazing season than at the end of the wintering period. All cattle that received protein supplements during the winter were heavier than the non-supplemented animals the following fall.

THE FEEDING OF CHLORTETRACYCLINE FOR THE CONTROL OF CERVICAL ABSCESSES IN SWINE. H. E. Gouge, R. G. Eggert, O. K. Van Roekel, D. D. Johnson and R. F. Elliott, *American Cyanamid Company.*

Observations were made on the occurrence of cervical abscesses, gains and feed efficiency of 429 pigs fed various levels of chlortetracycline in three controlled experiments conducted under farm conditions. In the first experiment where 75

pigs per treatment were fed from 15 to 200 lb., no cervical abscesses were visible. However, when marketed 72% of the pigs fed 12.5 gm. chlortetracycline per ton of feed had abscesses, while only one pig in the group receiving either 25 or 50 gm. had abscesses. The pigs receiving 12.5, 25 or 50 gm. chlortetracycline per ton of feed gained 1.25, 1.43 and 1.46 lb. per day and required 3.50 3.33 and 3.27 lb. of feed per lb. of gain, respectively. A subsequent experiment was conducted on a farm where cervical abscesses had been severe. Groups of 35 weaned pigs were fed 0, 50, or 100 gm. chlortetracycline per ton of feed from approximately 40 lb. to market weight. Abscesses were visible in approximately 20% of the pigs at the start of the experiment. At slaughter there was no significant difference in incidence of cervical abscesses between the two groups fed chlortetracycline. Cervical abscesses caused the condemnation of 25% of the heads in the chlortetracycline groups but 66% in the control group. The average daily gains were 1.51, 1.75 and 1.85 lb. respectively for the groups receiving 0, 50 and 100 gm. chlortetracycline, and there was an accompanying improvement in feed efficiency. This experiment was repeated on the same farm and similar results were obtained.

CAUTIONS REGARDING THE USE OF ANTHRAQUINONE VIOLET AS AN INDICATOR IN DIGESTION TRIALS AND ABSORPTION STUDIES. W. P. Flatt, D. J. Horvath, L. C. DeCosta, R. G. Warner and J. K. Loosli, *Cornell University*.

Anthraquinone violet (AQV) has been recommended and used successfully as an inert indicator for digestion studies with lambs (J. Animal Sci., 10:574, 1954). Preliminary open-abdomen absorption studies were conducted with three anesthetized calves in which the rumen was ligated at the proximal and distal ends. Circulation was intact to and from the organ. AQV was prepared as an aqueous colloidal suspension and placed in the rumen along with solutions of volatile fatty acids (VFA). After periods of at least one hour an average of only 72.4±6.4% of the AQV was recovered. The AQV was absorbed at a faster rate than the VFA. This observation was confirmed using intact, fistulated calves. In digestion trials with swine, crystalline AQV was fed at 0.025% of the diet. After 3 months of feeding the pigs were slaughtered. All carcasses showed extensive violet coloration, particularly in the fatty tissues and were rejected by the meat inspector. In a second group of pigs, the color persisted for as long as 7 months after the AQV had been removed from the feed.

FACTORS AFFECTING THE NUTRITIONAL COMPOSITION OF ALFALFA. Edward J. Thacker and Hugo O. Graumann, *U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York and Forage and Range Section, Beltsville, Maryland. ARS.*

Chemical and bioassay techniques were used to evaluate the nutritive quality of two varieties of alfalfa (Ranger and Buffalo) produced and harvested for two years with two cuttings a year in four widely different locations. At each location (Ithaca, New York; Lincoln, Nebraska; Brawley, California; and Raleigh, North Carolina), a randomized split block design in three replications was used. A common seed source, harvest at one-quarter bloom, hay cured without weathering and standard sampling procedures were stipulated for each location. Botanical composition of the crop, leaf to stem ratios, mineral and proximate composition of the alfalfa leaves and stems were determined on plot samples. Replications within a variety were combined from a location and ground to furnish material for rabbit feeding trials. The influence of variety, season and the location-variety and location-seasonal interactions on alfalfa composition were relatively

minor. The mineral and proximate components of the alfalfa and its parts was markedly influenced by location. A ration composed of alfalfa—91, hydrogenated vegetable oil—8, NaCl—1%, was used to compare the alfalfas in a ten-week growth trial with Dutch-belted rabbits four weeks of age. The alfalfa grown in North Carolina and California resulted in a greater gain in weight of the rabbits with less feed consumed than with those crops produced in New York and Nebraska. Weight gains were not significantly correlated with the mineral composition of the alfalfa. Positive correlations ($P<0.01$) were found between gain in weight of the rabbits and leafiness, ether extract and nitrogen-free extract of the alfalfa; and were negatively correlated ($P<0.01$) with the crude fiber content.

THE PHOSPHORUS REQUIREMENT OF CALVES. M. B. Wise, S. E. Smith and L. L. Barnes, *Cornell University*.

Forty Holstein male calves were used in two experiments to determine the phosphorus requirement. At 12 wk. of age the calves were changed from a grain-hay pre-experimental ration to a semi-purified basal ration containing 0.09% phosphorus. In each experiment there were 4 treatment groups consisting of 5 replications. The calves were individually fed *ad libitum*. Dicalcium phosphate was added to the daily ration to supply different levels of phosphorus. At the beginning of the 6-wk. test periods, 2 millicuries of Ca^{45} was injected intravenously in order that autoradiographs might be made to measure bone growth. Mean values for total weight gains in lb. femur growth in square inches, total feed intake in lb., feed/gain and terminal serum inorganic P in mg. percent for the different phosphorus levels fed in Experiment I were, respectively: *0.09% P,* 34, 0.82, 203, 6.37, 4.2; *0.12% P,* 38, 0.83, 203, 5.65, 4.3; *0.18% P,* 57, 1.01, 246, 4.27, 5.8; *0.30% P,* 64, 1.08, 252, 3.97, 9.2. Mean values for criteria listed above for the phosphorus levels fed in Experiment II were, respectively: *0.14% P,* 37, 0.78, 218, 5.89, 4.9; *0.22% P,* 51, 1.00, 245, 4.81, 6.7; *0.30% P,* 52, 0.93, 245, 4.73, 8.4; *0.38% P,* 49, 0.96, 238, 4.83, 8.1. Other measurement criteria used were rib autoradiographs, serum phosphatase, percent ash in 9th rib, percent P in rib and ash of rib, total rib wt., and increase in ht. at withers. The phosphorus requirement for calves of this age (12–18 wk.) and weight (200–275 lb.) approximates 0.22% of the air-dry ration.

THE RELATION OF ENERGY-PROTEIN RATIO TO PERFORMANCE AND CARCASS COMPOSITION OF SWINE. A. J. Clawson, E. R. Barrick and T. N. Blumer, *N. C. State College*.

Thirty-six pigs averaging 29 lb. were individually fed rations containing 0, 10 and 20% of added animal fat. The three fat levels were each fed in rations containing 8,000 9,500 and 11,000 Calories per pound of protein. Increasing levels of animal fat in the ration resulted in daily gains of 1.49, 1.58 and 1.69 lb. and feed required per pound of gain was 3.77, 2.98 and 3.06 lb. respectively. Pigs receiving rations containing the lower protein-energy ratio gained faster than pigs on higher ratios to a weight of 75 lb. (1.39, 1.27 and 1.23 lb. daily gain respectively). However, little difference attributable to protein-energy ratios existed in daily gains (1.60, 1.60 and 1.55 lb.), or in feed required per pound of gain (3.24, 3.32 and 3.35 lb.) for the entire fattening period. The pigs were slaughtered at an average weight of 210 lb. and one-half of the carcass, minus the bones, was ground and analyzed for moisture, ether extract and protein. In this trial the added dietary fat did not produce an increase in body fat when fed at the 8,000 Calorie level. At the 9,500 and 11,000 Calorie-protein ratios, the added fat resulted in an increased body fat. The average percent carcass fat associated with increasing levels of

dietary fat over all energy-protein ratios were 48.8, 49.3 and 52.0% respectively. Increasing protein-energy ratios resulted in an increase in deposition of body fat independent of the fat level in the ration (49.2, 49.6 and 51.5% respectively).

INFLUENCE OF FREQUENCY OF FEEDING EQUALIZED INTAKES ON ANIMAL RESPONSE. R. D. Mochrie, W. E. Thomas and H. L. Lucas, *North Carolina State College.*

Two groups of 4 Holstein steers each, were used in a simple-reversal trial with two 6-wk. periods. The steers averaged 188 days of age and 320 lb. at the start of the trial. The treatments were: feeding the entire daily ration at 7 a.m. (1×) or in four equal portions between 7 a.m. and 7 p.m. (4×). The av. daily intake of grain and grass hay for steers on (1×) was 4.0 and 6.3 lb. and on (4×) was 4.0 and 6.2 lb. The av. daily gain on the two treatment regimes was 1.03 lb. for (1×) and 1.21 for (4×). This difference in gain of 0.18 was highly significant ($P<0.01$) and had a 95% C.L. of 0.08 to 0.30 lb. per day. Twelve Holstein 1st calf heifers were used in a three period (6 wk. each) switchback trial to test the utilization of a concentrate-alfalfa hay ration when fed twice (2×), four (4×) or eight (8×) times daily. The av. grain and hay consumed daily was for (2×) 10.2 and 25.1, for (4×) 10.3 and 25.3, and for (8×) 10.3 and 25.2. No significant differences were found for actual milk, fat, FCM or % fat or in live weight changes for the three feeding frequencies. The av. lb. FCM produced daily were 29.4, 29.6 and 29.4 and av. weight changes per 6 wk. period were 18, 26 and 32 lb. for (2×), (4×) and (8×), respectively. At the frequencies studied, frequent feeding of equal daily intakes appears to increase feed utilization for growth but not for total energy output by lactating heifers.

PELLETED FEEDS FOR SWINE. III. EFFECT OF CRUDE FIBER AND KERNEL PLUMPNESS OF BARLEY. W. E. Dinusson, P. A. Nystuen and D. W. Bolin. *North Dakota Agricultural Experiment Station.*

Experiments at this station have shown a 12 to 15% increase in daily gains and 14 to 20% increase in feed efficiency as a result of pelleting barley rations for pigs. The effect of kernal plumpness was studied in two experiments. The basal ration was barley 95.1; meat scraps 1.5; blood meal 1.5; limestone 0.4; trace mineral salt 0.5; and steamed bone meal 1.0 plus vitamins and minerals. The barley was sized by seives 6/64 × 3/4 and 5/64 × 3/4. The gains on the basal barley ration (45.5 lb. per bu.), thin barley (37 lb.) or plump barley (47 lb.) were: 1.49, 1.50, and 1.47 lb. per day respectively (av. 2 reps.). It took 3.06, 3.31, 3.22 lb. feed per lb. of gain respectively for these pelleted rations. In trial 2 the same treatments gave gains of 1.55, 1.61, and 1.53 lb. per day, (av. 2 reps.) with feed requirements of 3.71, 3.57, and 3.44 per lb. of gain. Two other treatments were included in trial 2—the thin and plump barley rations in meal form. Pigs on the "thin" pellets gained 18.5% faster on 21.3% less feed than on meal rations and pigs on the "plump" pellets gained 12.6% faster on 30.8% less feed than those fed the meal rations. In two trials oat hulls were added to increase the fiber content. The treatments were (1) basal pellet, (2) basal meal, (3) 15% oat hulls pellet, (4) 15% oat hulls meal and (5) 30% oat hulls pellet. The basal ration was same as used in previous trials. The fiber content, daily gain, and feed per lb. of gain were respectively (av. 2 exp., 2 reps. each), (1) 7.6%, 1.46 lb., 3.69 lb.; (2) 8.2%, 1.39 lb., 4.28 lb.; (3) 10.5%, 1.57 lb., 4.00 lb.; (4) 11.9%, 1.34 lb., 5.21 lb.; (5) 14.4%, 1.50 lb., 4.66 lb.

ISOLATION AND IDENTIFICATION OF COMPOUNDS FROM AUTOLYZED YEAST, ALFALFA MEAL, AND CASEIN WITH CELLULOLYTIC FACTOR ACTIVITY FOR RUMEN MICRO-ORGANISMS *IN VITRO*. Burk A. Dehority, Orville G. Bentley, Ronald R. Johnson and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Certain natural materials, such as casein, alfalfa meal, dried distillers solubles, and autolyzed yeast have been shown to contain unidentified cellulolytic factor(s) for rumen micro-organisms *in vitro*. The volatile short-chained fatty acids which were previously found, in our laboratory, to be the major active factors in rumen juice are not present in appreciable amounts in these materials. Hot water extracts of autolyzed yeast and alfalfa meal were purified by passage through a Dowex-50 ion exchange bed and a charcoal (Darco G-60) bed. The cellulolytic factor activity, as determined by an *in vitro* rumen fermentation, was found consistently in the fraction of the extracts which contained the amino acids. The active fractions from these extracts and casein hydrolysate (acid) were subjected to large scale unidimensional paper chromatography using 80% phenol in water as a solvent. The chromatograms were then divided into two sections and eluted with hot water. The eluates from the top portion of these phenol chromatograms were found to contain all the cellulolytic factor activity of the extracts. Paper chromatographic analysis of the active eluates from all three materials showed that the amino acids, proline, valine and the leucines, were always present in significant amounts. Pure samples of these amino acids alone and in various combinations, were found to have sufficient cellulolytic factor activity to account for the stimulation obtained from the natural materials studied.

THE CELLULOLYTIC ACTIVITY OF ORGANISMS ASSOCIATED WITH DRIED FORAGES. Orville G. Bentley and A. L. Moxon, *Ohio Agricultural Experiment Station.*

Cellulose of alfalfa hay was found to disappear when fermented in the artificial rumen apparatus, even though the inoculum of rumen micro-organisms was not added. The amount varied from sample to sample but from 20 to 50% reduction in cellulose occurred based on the results of cellulose analyses. This was observed for samples collected during 1955 and 1956 from three different locations. Since a bacterial contamination on the sample was suspected, the effect of various bacteriostatic agents on this "self-digesting" process was investigated. Phenol and formaldehyde (0.25 to 1.0 gm. per ml. fermentation mixture), toluene (0.5 ml. per 100 ml. added at 4 time intervals during a 30-hour fermentation), and procaine penicillin or chlortetracycline (5 mg. per 100 ml.) completely inhibited the "self-digestion" of the cellulose and markedly reduced bacterial numbers, as estimated by direct count of smears stained with methylene blue. Autoclaving the hay samples reduced "self-digesting" appreciably. Experiments using autoclaved and unautoclaved hay as sources of cellulose were carried out to determine if this "self-digestion" would exert an additive effect on cellulose digestion in the presence of rumen micro-organisms *in vitro*. Slightly more cellulose (10%) was digested in the flasks containing the unautoclaved hay but other factors, such as the effect of heat, may have been involved. This problem of "self-digestion" in the artificial rumen does not occur with isolated alfalfa hay cellulose or purified wood cellulose. Likewise, in the presence of rumen organisms, the "self-digestion" associated with forage samples did not appear to contribute materially to the total cellulolytic activity in the artificial rumen flasks.

EFFECT OF ADDED FAT ON THE UTILIZATION BY STEERS OF NITROGEN IN WINTERING RATIONS. N. W. Robinson, Willis D. Gallup and A. B. Nelson, *Oklahoma Agricultural Experiment Station.*

Studies of the protein sparing action of added carbohydrate and fat in ruminant rations have been continued in a series of nitrogen balance trials. The subjects were Hereford steers fed a basal wintering-type ration (9.5% protein, dry matter basis) of prairie hay, 3000 gm., cottonseed meal, 454 gm. and complex minerals. Finely ground corn was used as a source of added carbohydrate and refined corn oil as a source of added fat. In the trials with added carbohydrate, 118 gm. of cottonseed meal was replaced by an isonitrogenous amount of corn, 572 gm., representing the addition to the basal ration of an extra 355 gm. of non-nitrogenous nutrients, mostly carbohydrate. In the trials with fat, 200 gm. of corn oil was added directly to the cottonseed meal of the basal ration. The supplement of corn decreased nitrogen excretion in the urine but increased it in the feces. The increased fecal nitrogen excretion was associated with the increased intake and excretion of dry matter and a lower digestibility of crude fiber. In this respect, results resembled those obtained with pure carbohydrate in earlier work. Total N retention was decreased from 24.2% of the intake to 22.5%. The supplement of fat decreased urinary nitrogen excretion without affecting fecal nitrogen excretion. Total N retention was increased from 21.1% of the intake to 24.7%. The associative effect of different feeds and supplements on digestibility is an important factor in studying nitrogen utilization.

SUPPLEMENTS TO HIGH-SILAGE RATIONS FOR FATTENING YEARLING STEERS. L. S. Pope, J. R. LeGendra, R. D. Humphrey and V. G. Heller, *Oklahoma Agricultural Experiment Station.*

Eight supplemental mixtures were compared to soybean meal in three 160-day fattening trials involving 180 steers. A "two phase" feed-program was followed in which the control lot received 4 lb. of ground milo per head daily during the first half of the trial and a full-feed during the finishing phase, with 2 lb. of soybean meal throughout the test. Silage (sorghum in two trials and immature corn silage in one) was fed *ad lib.* during both phases. Protein and energy intakes from the concentrates fed all lots were equalized by adjusting the amounts of milo and supplement fed the experimental groups. In two trials, Purdue supplement A failed to improve rate of gain, feed efficiency, or carcass grade. The same was true for 3–1–1 and 1–1–1 mixtures of soybean meal, chopped alfalfa and blackstrap molasses. A special mixture containing dehydrated alfalfa meal, dried molasses, condensed fish solubles, live cell yeast and trace minerals did not improve steer performance in two trials. In one trial, feeding a mixture of soybean and sesame meals (2:1 ratio) or the addition of 0.5 lb. of fermentation solubles did not improve gains, while 90 mg. of aureomycin (in the crude product) gave a slight, but not significant improvement. Diethylstilbestrol (10 mg. per steer daily) significantly improved gains and was more beneficial when fed throughout the trial than when fed only during the finishing phase. It appears that the silage fed, supplemented with soybean meal, contained ample nutrients for rumen bacteria as measured by steer gains.

AVAILABILITY OF PHOSPHORUS IN MINERAL SUPPLEMENTS FOR BEEF CATTLE. T. A. Long, A. D. Tillman, A. B. Nelson, Willis D. Gallup and Bill Davis, *Oklahoma Agricultural Experiment Station.*

Two feeding trials were conducted with grade Hereford steers to compare the effects of different percentages of supplemental phosphorus on feed consumption,

weight gain and inorganic phosphorus in the plasma as measures of phosphorus nutrition. The steers were individually fed low-phosphorus (0.07 and 0.09%) rations alone and supplemented with NaH_2PO_4 in amounts to provide from 0.11 to 0.19% total phosphorus. Feed intake, weight gain and plasma phosphorus increased in a linear manner (statistically significant) with increased amounts of supplemental phosphorus in the ration over the range of 0.07, 0.11, and 0.15% but not including 0.19%, total phosphorus. Plasma phosphorus was especially sensitive to change in phosphorus intake but showed periodic variation. Steamed bone meal, Curacao Island phosphate and dicalcium phosphate were compared as sources of phosphorus with heifers fed rations containing a total of 0.15% phosphorus. Heifers on the 0.07% basal ration declined in feed intake, made small gains, and their plasma phosphorus decreased. Those on the supplemented rations were normal according to these criteria, and any difference between them related to phosphorus source was not statistically significant. The results indicated equal availability of phosphorus in the three supplements.

THE EFFECT OF SOYBEAN MEAL ASH OR VITAMINS OF THE "B" COMPLEX GROUP UPON THE GROWTH OF SHEEP RECEIVING PURIFIED Diets. Walter R. Woods and A. D. Tillman, *Oklahoma Agricultural Experiment Station.*

In the course of studying factors associated with urea utilization by ruminants it was found in iso-nitrogenous "purified diets" that soybean meal promoted faster growth in sheep than either Drackett protein or crystalline urea; the daily gains were .26, .13, and —.10 for soybean meal, Drackett, and urea, respectively. Two feeding trials involving 60 individually-fed sheep weighing about 50 lb. were conducted to test the effect of soybean meal ash and a mixture of "B" complex vitamins (rat requirements) upon gains when consuming a purified diet. The basal diet consisted of cellulose (solka floc), "complete" mineral mixture, crystalline urea, starch, cerelose, vitamins A, D, E, and choline chloride. In trial 1 the treatments were: basal; basal + soybean meal ash; basal + "B" vitamins; basal + "B" vitamins + soybean meal ash; basal + corn oil; basal + corn oil + soybean meal ash, respectively in ration 1, 2, 3, 4, 5, and 6. The daily gains (lb.) and feed consumption (gm.) were: 0.02, 625; 0.18, 992; 0.14, 947; 0.21, 1053; 0.05, 607; 0.15, 828, respectively. In trial 2 the first four rations were repeated; ration 5 contained the basal + complete mineral mixture (equal to amount of soy ash). Ration 6 contained the basal + trace minerals (Mo, Br, and B). Daily gains and feed consumption values were: —0.03, 660; 0.06, 910; 0.05, 724; 0.08, 850; —0.04, 576; —0.08, 509; respectively. Soybean meal ash significantly increased gains in individual trials; "B" vitamins significantly increased gains when the trials were combined. Neither the additional complete mineral mixture nor the additional trace minerals increased gains.

CHROMIUM OXIDE, CHROMOGEN AND PROTEIN EXCRETION PATTERNS OF BEEF STEERS WHEN FED MOUNTAIN MEADOW HAY. J. E. Oldfield, W. F. Brannon, W. A. Sawyer, W. W. Ellis, R. R. Wheeler and Mary E. Cribby, *Oregon State College and Squaw Butte Experiment Station.*

Four Hereford steers were individually fed daily a ration of 11 lb. of chopped rush-sedge mountain meadow hay for 28 days. During the three months preceding this trial they had been wintered on this wild meadow hay and some alfalfa. The steers' average initial weight was 542 lb. and terminal weight was 545 lb. From the 15th to the 28th day inclusive a 5.00 gm. capsule of Cr_2O_3 was given orally at 7:00 a.m. daily. During the last 5 days and nights of the trial "grab" fecal samples

were taken from the colon of each steer at 2 hour intervals. These "grab" samples were analyzed for chromogen, Cr_2O_3, protein and moisture content. Cyclic patterns of excretion were manifest by these components. Chromium oxide was excreted in a diurnal pattern similar to that reported by other research workers. In agreement with an earlier report from Oregon, chromogen also appeared to be excreted in a diurnal manner. The average recovery of Cr_2O_3 from the feces of the 4 steers was 93.2% The cyclic excretion concentrations of all components will be discussed as to their possible use and significance.

THE EFFECT OF DIFFERENT LEVELS OF ANTIBIOTIC SUPPLEMENTATION FOR GROWING-FINISHING SWINE. Richard C. Wahlstrom, *South Dakota State College.*

Four trials involving 168 weanling pigs have been conducted to study the effect of antibiotics fed for varying lengths of time at different levels. The practical type basal ration used was composed of ground yellow corn, soybean oil meal, tankage, and minerals supplemented with B-vitamins. In trial 1 the following supplementation was made to the basal ration: Lot I, none; Lot II, 100 gm. chlortetracycline per ton of ration; Lots III, IV, and V, 25, 50, and 100 gm. of penicillin-streptomycin mixture (1:3) per ton of ration, respectively. In trial 2 chlortetracycline was fed at the following levels: Lot I, none; Lot II, 10 gm. per ton; Lot III, 100 gm. per ton to 100 lb., then none to 200 lb.; Lot IV, 100 gm. per ton to 100 lb., then 10 gm. per ton to 200 lb.; Lot V, 100 gm. per ton for entire trial. The same treatments were used in trial 3 except that penicillin-streptomycin mixture was used as the antibiotic in place of chlortetracycline. Additions to the basal ration in trial 4 were as follows: Lot I, none; Lot II, 10 gm. chlortetracycline per ton; Lot III, 100 gm. chlortetracycline per ton for 4 wk., then 10 gm. per ton to 200 lb.; Lot IV, 100 gm. chlortetracycline per ton; Lot V, 100 gm. streptomycin-sulfaquinoxaline mixture (1:1) per ton; Lot VI, 100 gm. sulfaquinoxaline per ton. All treatments increased average daily gains and the high levels of supplementation improved gains over lower levels particularly during the initial weeks of the trials.

THE EFFECT OF FLUORIDE ON CARBOHYDRATE METABOLISM IN ANIMALS. C. C. Chamberlain, Sam L. Hansard, C. S. Hobbs, H. Patrick and Wise Burroughs, *The University of Tennessee.*

Twenty-one Hereford cows, eight suckling pigs, two lambs and 122 weanling and mature rats were employed in a study of the effects of chronic and acute levels of fluoride upon blood and/or tissue changes in glucose, glycogen and lactate content. In lambs and pigs administered 200 mg. per kg. NaF intraperitoneally or subcutaneously blood glucose and lactate levels increased regularly two to four times over predosing levels within 2.5 to 5 hours after dosing. Beef cows maintained 6 to 8 years on 8, 58 and 108 ppm dietary F showed no effect of past fluoride intake on blood lactate in samples taken 2 hours after feeding. However, 24 hours after current F ingestion, there was a trend toward decreased lactate level with increased F intake. Weanling and mature rats receiving 300 ppm F added to a semipurified diet and sacrificed at intervals over a 12 week period for comparison with littermate controls receiving the same diet without added fluoride indicated: 1) a marked drop in blood glucose of 20–35% in both age groups. 2) Mature rats recovered within a week to the pre-fluoride blood glucose levels while weanling rats required 2–3 weeks to recover to a point 10–15 mg. percent below that of the control animals and then maintained this lower level for the remainder of the 12-week period. 3) Liver and muscle glycogen changes reflected the blood glucose picture, with less effect noted in mature animals. 4) Wide variations were noted in

the blood lactate levels for all groups. The results of these findings will be discussed as they may reflect the mode of fluoride action upon carbohydrate metabolism in young and mature animals.

UPTAKE AND DEPLETION OF FLUORINE IN BONES OF COWS SUBJECTED TO INCREASED LEVELS OF FLUORINE FOR VARIABLE PERIODS. J. M. Griffith, C. S. Hobbs, G. M. Merriman and W. H. McIntire, *University of Tennessee.*

The uptake, depletion and alleviation of fluorine was studied in cattle and sheep fed various levels of fluorine. Some of these experiments were conducted over a short period of time (five months) and some over an extended period of time (six years). The results of these cattle and sheep experiments show: (1) The fluorine content in the skeleton increases as the fluorine content in the ration increases. (2) The fluorine content of the skeleton increases with the length of time that an animal consumes a given level of fluorine. (3) The skeleton will become saturated with fluorine after the animal consumes a given level of fluorine for a certain period of time. (4) Fluorine is transferred through the placenta in small amounts; however, there appears to be little correlation between the amount transferred and the amount in the skeleton of the dam or the level of fluorine consumed by the dam. (5) The addition of aluminum sulfate or aluminum chloride to the ration of animals receiving fluorine decreases the amount of fluorine stored in the skeleton. (6) Less fluorine is stored in the bone from a raw rock phosphate source than from a sodium fluoride source. (7) There is a rapid uptake of fluorine in the bones when animals consume forage containing high fluorine and a much slower depletion when animals are taken off high fluorine feed and put on control feed. (8) When the skeleton of an animal is saturated with fluorine and then the fluorine intake of the animal is materially reduced, the leg bone generally has the greatest concentration, the rib less and the mandible the least concentration.

UREA IN PROTEIN SUPPLEMENTS FOR WINTERING BEEF CATTLE. R. A. Reynolds, M. C. Bell, C. S. Hobbs and J. M. Bird, *University of Tennessee.*

Two winter feeding trials were conducted to compare the value of urea and cottonseed meal, cottonseed meal, and Purdue supplement A when fed with corn silage and grass hay or with hay alone. In each trial ten lots of ten heifers each were used. Protein supplements were pelleted and fed at the rate of one pound per head per day to all lots. The supplements containing urea were 7% urea. The various supplements for lots 1 through 10 were as follows: cottonseed meal; CSM and corn, CSM, urea and corn; CSM, urea, corn and molasses; Purdue supplement A; CSM, urea and corn; CSM and corn; CSM, urea and corn; CSM, urea, corn and molasses; Purdue supplement A. In each trial, the first six lots were fed all the corn silage they would consume plus a limited amount of hay and the other four lots received all the hay they would consume. Supplements one and six contained 41% protein, others contained 32%. Average daily gains and feed cost per cwt. gain for Lots 1 through 10 were: Trial 1—1.58, 14.46; 1.43, 16.07; 1.47, 15.53; 1.52, 15.11; 1.56, 14.76; 1.46, 15.97; 0.93, 26.06; 0.99, 24.62; 0.97, 24.37; 1.01, 23.70. Trial II—1.25, 14.63; 1.06, 16.35; 1.06, 16.06; 0.92, 18.50; 1.10, 15.99; 1.00, 17.26; 0.44, 34.77; 0.54, 27.96; 0.34, 45.61 and 0.43, 36.88. There were no significant differences among lots on the same roughage; however, the corn silage—hay lots made significantly better gains than did the hay lots on each trial. The heifers fed the corn silage and grass hay were two-thirds of a grade higher in condition than the ones fed hay. On the average urea was effective in replacing a part of the cottonseed meal in these supplements.

STILBESTROL AND THE PHYSIOLOGICAL BEHAVIOR OF Ca-45 AND P-32 IN SHEEP. Joseph D. Shroder and Sam L. Hansard, *University of Tennessee.*

Twelve wether lambs and six mature wethers were employed in a study of the effects of dietary diethylstilbestrol upon the physiological behavior of calcium and phosphorus. Concurrent 7-day chemical and radio-chemical balance and blood studies were made, using calcium^{54} and phosphorus^{32} simultaneously, at periodic intervals during an 8-day feeding trial. Oral administration of 2 to 4 mg. of stilbestrol per head daily had no apparent effect upon blood levels of calcium or phosphorus and failed to influence materially the rate of blood disappearance of calcium^{45} or phosphorus^{32}. In lambs, stilbestrol decreased fecal endogenous loss of calcium approximately 15% which was reflected in the true digestibility values for dietary calcium. A similar trend was noted using mature wethers, but, due to greater endogenous calcium and phosphorus losses and greater variability in the older animals, the data were less conclusive. Data obtained through the use of phosphorus^{32}, at this point, were inconclusive for both age groups. Consideration will be given to the application of the results of these studies for the elucidation of the mechanism of action of stilbestrol in sheep.

VOLUNTARY FEED CONSUMPTION BY RUMINANTS: VARIATIONS IN THE VOLUNTARY CONSUMPTION OF A FORTIFIED UREA-MOLASSES-PHOSPHORIC ACID MIXTURE BY SHEEP AND CATTLE SELF-FED EITHER JOHNSON GRASS HAY OR COTTONSEED HULLS IN DRY LOT. W. T. Berry Jr., T. D. Watkins Jr., J. K. Riggs and H. O. Kunkel, *Texas Agricultural Experiment Station.*

A liquid supplement composed of 10% urea and 90% molasses was self-fed to pregnant and lactating Brahman cows and open Rambouillet yearling ewes. Twelve cows and 27 ewes were divided into two and three groups, respectively, and individually fed. Johnson grass hay and cottonseed hulls were fed to the cows in a self-fed, restricted hand-fed reversal type experiment of the Latin Square design. In a similar reversal type experiment, alfalfa hay, as well as Johnson grass hay and cottonseed hulls were self-fed and restricted hand fed to the ewes. The average daily consumption of urea-molasses was 8.1 lb. with individual averages ranging from 6.7 to 10.1 lb. for the cows, and the average daily consumption of urea-molasses was .76 lb. with individual averages ranging from .38 to 1.40 lb. for the ewes. During each 7-day period that the roughage was restricted the consumption of urea-molasses supplement was significantly increased. The maximum daily consumption of urea-molasses by one cow was 14.8 lb. representing 1.5 lb. of feed grade urea, and the maximum daily consumption of urea-molasses by one ewe was 2.2 lb. representing 100 gm. of feed grade urea. These are higher levels than have been reported, but no irregularities occurred. The voluntary consumption of urea molasses was significantly altered by the kind of roughage consumed.

THE VALUE OF CERTAIN CARBONATED CRUDE PHOSPHOLIPIDS AS ADDITIVES TO RATIONS FOR FATTENING BEEF CATTLE. C. M. Kincaid, W. S. Wilkinson, J. C. Taylor, B. M. Priode, and Martin J. Burris, *Virginia Agricultural Experiment Station and U.S.D.A.*

A series of three feeding trials with a total of 82 steers was conducted to determine the value of crude phospholipid by-products of cottonseed, and soybean oil processing, in rations for fattening beef steers. The amount of the additives used included .75%, 1.5%, and 3.0% of the total ration on a dry weight basis. The

basal rations used contained from 50% to 70% concentrate with the remainder being hay. Steers were fed in dry lot for 154 or 196 days and in one trial half the steers were fed on pasture an additional 152 days.

In all trials calves receiving the phospholipid additives gained faster than comparable controls. Increased gains ranged from 1.7% to 17.7% in the various trials when the animals on the basal ration were compared with animals receiving the additive in the various trials. The average increase from using the additive was 5.5%, in no trial were the increased gains significant. The feed required per pound of gain with the use of the additive when expressed in percent of the control ranged from 102.0% to 88.0% for lots in the various trials with a weighted average of 96.2%. There were no apparent harmful effects due to any of the phospholipid materials in the concentrations used upon gain and feed efficiency or other economic characteristics in the live animal or in the carcass. In the opinion of the authors the consistent increases in average daily gain, increases in feed efficiency, and apparent absence of harmful effects on the animal indicate that the phospholipids tested are desirable additives to rations for fattening beef cattle.

THE EFFECT OF A HIGH-PROTEIN, HIGH-POTASSIUM RATION ON THE MINERAL METABOLISM OF LAMBS. J. P. Fontenot, R. W. Miller, C. K. Whitehair and Robert MacVicar, *Oklahoma Agricultural Experiment Station.*

In an experiment on the etiology of "wheat pasture poisoning," the effect of a high-protein, high-potassium ration on the mineral metabolism of sheep was investigated. Six western wether lambs were fed a ration of normal protein and potassium content (ration 1) and six were fed a ration of high protein and potassium content (ration 2). The two rations were designed to furnish approximately the same amounts of Ca, P and Mg per day. Ration 2 was similar to lush wheat pasture in crude protein, Ca, P, Mg, Na and K content. Both rations were composed of alfalfa hay, yellow corn and purified ingredients. Approximately 25 days were required to get the lambs on a constant feed intake after which two 20-day balance trials were conducted. During a 10-day adjustment period between the trials the rations were modified slightly and feed allowance was increased. Feeding the high-protein, high-potassium ration resulted in a 48% increase in fecal Mg excretion in trial 1 and a 47% increase in trial 2. Urinary Mg excretion was decreased and the net result was a slightly lower average Mg retention. Also, animals fed the high-protein, high-potassium ration had, on the average, a lower average plasma Mg concentration. Fecal excretion of Ca and P was decreased and the retention of these nutrients was increased when ration 2 was fed. Plasma Ca was decreased and plasma P was increased. It appears that the feeding of a high crude protein and/or a high potassium ration to lambs depresses Mg absorption and may affect the metabolism of other minerals.

HEPATIC AND PLASMA LEVELS OF VITAMIN A IN GESTATING-LACTATING HEIFERS AS AFFECTED BY VARIOUS LEVELS OF CAROTENE INTAKE. W. K. Roberts, I. A. Dyer and M. E. Ensminger, *Washington State College.*

Forty-five Hereford heifers were artificially bred and allotted into nine treatment groups according to number of days pregnant and body weight. Each animal was supplemented with a mixture of ground wheat, salt, bone meal and molasses. Group 1 was full-fed alfalfa hay while group 2 was full-fed wheat straw. In addition, groups 3 to 9 were full-fed wheat straw and were supplemented as follows: (3) alfalfa meal, (4) alfalfa ash, (5) alfalfa meal and alfalfa ash, (6)

urea, (7) alfalfa meal and urea, (8) alfalfa ash and urea and (9) alfalfa meal, alfalfa ash and urea. Carotene intakes were approximately 140, 30 and 0 mg. per head daily for the alfalfa hay, alfalfa meal and straw fed groups, respectively. The rate of loss in hepatic stores of vitamin A was significantly lower in the heifers receiving wheat straw and alfalfa meal when compared to those not receiving alfalfa meal. However, there was no significant difference in plasma vitamin A among these groups. The condition of the calves at birth was considered normal. There was no significant difference in liver or plasma levels of vitamin A of calves at birth or at 56 days of age, regardless of the levels of carotene intake during gestation. Appreciable amounts of vitamin A were found in the colostrum of all cows and some vitamin A was found in the milk at 56 days post-partum irrespective of their carotene intake during gestation.

EFFECTS OF SODIUM BENTONITE ON CAROTENE UTILIZATION BY STEERS WITH *IN VITRO* STUDIES. E. S. Erwin, C. J. Elam and I. A. Dyer, *Washington State College.*

Eighty mcg. of carotene were dissolved in 20 ml. of petroleum ether. Increasing amounts of sodium bentonite were added to the above carotene solution and it was found that 0.75 gm. of sodium bentonite completely precipitated the 80 mcg. of carotene. Almost a straight line relationship existed between the amount of bentonite present and the amount of carotene tied-up. The effect of varying the pH was then tested by adding 0.1, 0.2, 0.3, 0.4, and 0.5 gm. of sodium bentonite to 3 mg. of carotene in solution. Every level of bentonite bound all of the carotene present. Altering the pH from 7 to 10.6 did not affect the amount of carotene bound. Twelve steers were fed a ration containing 25% dehydrated alfalfa. Six of the steers also received sodium bentonite at 3% of the ration. Liver samples were taken from all the steers at 0 and 100 days and analyzed for carotene and vitamin A content. There was no difference in hepatic carotene and vitamin A storage as affected by treatment. Since no difference resulted *in vivo* an additional *in vitro* study was conducted. Ether extracts from three 2 gm. samples of dehydrated alfalfa were diluted with petroleum ether and divided into 2 samples of each extract. Sodium bentonite (at the same level as the *in vivo* study) was shaken with half of the samples. The bentonite tied-up an average of 8.6% of the carotene present in the ether extract.

THE INFLUENCE OF DIETHYLSTILBESTROL, UREA AND BIURET UPON DIGESTIBILITY AND NITROGEN METABOLISM IN LAMBS. C. D. Campbell, G. A. McLaren, G. S. Smith, J. A. Welch, D. C. Shelton and G. C. Anderson, *West Virginia University.*

Three digestion and nitrogen metabolism experiments were conducted using semi-purified rations containing 1.60% nitrogen with wheat straw as the source of fiber. Two-thirds of the ration N was supplied by urea, crude biuret* or a combination of these materials. Four wether lambs were included in each treatment. All lambs fed diethylstilbestrol (DES) received 2 mg. daily. In experiment I, a single reversal, the influence of DES upon biological value, the apparent digestibility of nitrogen and organic matter was determined when the percentage of ration NPN contributed by urea was 100 and crude biuret and urea 50–50 and crude biuret 100. DES did not influence organic matter or protein digestibility but significantly (.05) improved N utilization. Experiment II was conducted to determine the effect of prolonged DES feeding upon organic matter and protein digestibility and nitrogen utilization when crude biuret supplied 100% of the ration NPN. Data from five successive 10-day collection periods showed organic matter

and apparent protein digestibility to be significantly (.05) depressed by DES. Improvement in biological value by DES approached significance (.08). Nitrogen utilization was increased in a linear manner with respect to time with and without DES. Experiment III was conducted to determine if DES influenced digestibility and nitrogen utilization after being withdrawn from the ration. Experiment III included two successive 10-day collection periods and was a continuation of II except that DES was not fed. Data show that any possible carry over effect of DES was lost within 10 days.

THE RELATIVE VALUE OF BIURET, CREATINE, SOYBEAN PROTEIN AND OTHER NITROGENOUS MATERIALS FOR LAMBS IN DIGESTION AND NITROGEN METABOLISM TRIALS. J. A. Welch, G. A. McLaren, G. S. Smith, C. D. Campbell, D. C. Shelton and G. C. Anderson, *West Virginia University*.

The value of six non-protein nitrogenous (NPN) compounds was determined in four conventional digestion and nitrogen metabolism trials in which two to four wether lambs were included in each treatment. Semi-purified rations containing 1.60% nitrogen were used with wheat straw as the source of fiber. Two-thirds of the ration nitrogen was supplied by an NPN compound alone or in combination with urea. Urea provided the major source of nitrogen in the control rations. The following compounds and the percentage of ration supplemental N supplied by each was as follows: urea-formaldehyde condensation compound (UFC) 2, 4, 8, 16, 32; crude biuret* 50, 100; pure biuret 100; creatine 33; soybean protein (Drackett) 15, 82. Above 2% UFC, a significant depression (.05) in apparent N digestibility occurred. None of the levels used affected organic matter digestibility or biological value. Crude biuret significantly depressed apparent N digestibility but was without effect on organic matter digestibility and nitrogen utilization. Pure biuret depressed digestibility of organic matter and protein and reduced the utilization of nitrogen. Creatine and soybean protein significantly enhanced N utilization when compared to that obtained with urea. Creatine compared favorably with soybean protein in increasing digestibility of organic matter and protein.

THE ACTION OF HIGH CALCIUM AND SELF-FEEDING IN AGGRAVATING PARAKERATOSIS. P. K. Lewis, Jr., W. G. Koekstra and R. H. Grummer, *University of Wisconsin*.

Two experiments were conducted to determine the effect of dietary calcium and methods of feeding on the development of parakeratosis in pigs and on the zinc content of various body components. In the first experiment a basal ration containing 14.5% protein, 0.5% calcium, 0.53% phosphorus and 300 ppm of zinc was fed. Increasing the calcium content of the ration to 0.8% or still further to 1.2% significantly decreased average daily gain (from 1.14 lb. to 0.80 lb. to 0.10 lb., respectively) while each of these increases hastened the onset of parakeratosis. Pigs fed the 0.5% calcium ration without added zinc gained as well as pigs fed the 0.8% calcium ration plus 100 ppm of zinc, but the addition of zinc prevented the appearance of any detectable signs of parakeratosis. The zinc supplementation significantly increased the zinc content of the plasma, liver, hair, bone and pancreas but not of intestine and skin. Increasing the calcium content of the ration produced

*Crude biuret contained 40.0% biuret, 45.5% urea, 6.7% triuret, 7.6% cyanuric acid and 0.3% water.

the following changes in the zinc content of various body constituents: no significant increase in plasma, pancreas, skin or intestine; significant increases in liver, kidney and hair; and a slight increase in bone. *In vitro* experiments indicated that high levels of calcium reduced the availability of zinc for adsorption or readsorption from the intestinal tract. In the second experiment a ration containing 14.5% protein, 1.4% calcium and 33 ppm of zinc was fed. Pigs fed this ration *ad lib.* and in the dry form gained an average of 0.21 lb. per day whereas those hand fed the ration in the wet form and in more than ample amounts gained an average of 0.43 lb. per day during the first 11 weeks of the comparison. Thereafter precautions were taken to feed the wet fed pigs only twice a day amounts which they could consume in about 30 minutes. In this later comparison the pigs receiving the wet feed gained an average of 0.83 lb. per day, whereas those receiving the dry mixture *ad lib.* gained an average of 0.35 lb. per day.

MINERAL VS. PHENOTHIAZINE SUPPLEMENTATION IN THE CONTROL OF STOMACH WORMS IN GRAZING SHEEP. R. J. Emerick, W. J. Bemrick, A. L. Pope, C. A. Herrick, and P. H. Phillips, *University of Wisconsin.*

Previous work at the Wisconsin Experiment Station has shown that trace minerals in combination with calcium and phosphorus reduced the detrimental effects of severe stomach worm infections in sheep. Experiments involving 123 grazing lambs, artificially infected with *Haemonchus contortus,* were conducted during the past 3 years to compare the protective effect of trace mineralized salt with and without dicalcium phosphate and/or phenothiazine. The four supplements used were as follows: Lot I, trace mineralized salt (basal); Lot II, basal + 25% dicalcium phosphate; Lot III, basal + 10% phenothiazine; Lot IV, basal + 22.5% dicalcium phosphate + 10% phenothiazine. The death loss of 31.2% resulting from haemonchosis in the control group (Lot I) was considerably higher than the 0%, 3.4%, and 6.2% death losses which occurred in Lots II, III, and IV respectively. The average weight gains were 35.0 lb., 40.3 lb., 43.9 lb., and 42.9 lb., and the average hemoglobin values 62 days after infection were 8.34, 10.37, 9.92, and 10.57 gm. per 100 ml. for the four groups respectively. These differences were significant when Lots II, III, and IV were compared to the controls (Lot I). In addition, both dicalcium phosphate and phenothiazine, when added to trace mineralized salt significantly reduced fecal egg counts and raised carcass grades. The average carcass grade of the control lambs was utility while those of the other three treatments averaged good. The results of these experiments show that dicalcium phosphate added to trace mineralized salt was comparable to the phenothiazine, trace mineralized salt mixture in protecting lambs against the detrimental effect of stomach worm infections.

Meats Section

T. N. BLUMER, *Chairman*

EFFECT OF FEEDING DARK BROWN SUGAR PRIOR TO SLAUGHTER ON PORK. M. C. Heck, *University of Arkansas.*

Weight loss of crossbred market hogs during shipping was markedly reduced by feeding dark brown sugar in the drinking water at the rate of 3 lb. per 5 gallons of water 48 hours prior to loading. In Trial I, 109 head averaging 203 lb. shrank .65% whereas 60 head averaging 200 lb. which received no sugar shrank

4%. In Trial II, 8 crossbred barrows and 4 crossbred gilts were slaughtered to determine the effect of sugar feeding on shrinkage, curing loss and palatability. Liver weights were heavier from hogs receiving sugar prior to slaughter. With a dry sugar and dry salt cure the cuts from hogs fed sugar lost less weight in curing and in smoking. The cooked hams and shoulders tested by a taste panel scored higher for aroma, flavor of fat, flavor of lean, texture, tenderness and juiciness. The Warner-Bratzler shear test ratings on the cooked samples were lower where hogs had been fed sugar prior to slaughter.

SOME FACTORS INFLUENCING YIELDS OF WHOLESALE AND RETAIL CUTS FROM BEEF CARCASSES. J. C. Pierce, C. L. Strong, M. M. Van Zandt and C. E. Murphey, *U. S. Department of Agriculture.*

Results are summarized of a study evaluating the significant effects of variations in grade, weight, sex, conformation, and finish on yields of wholesale and retail cuts. The 459 beef carcasses ranged from 200 to 1000 lb. in weight and from U. S. Prime through U. S. Canner in grade. A subjective evaluation of conformation and finish, in terms of grade, and detailed objective measurements designed to reflect differences in these factors were recorded for each carcass. Yields of cuts based on carcass weight included untrimmed wholesale cuts, retail cuts with an intermediate trim, and retail cuts with a close trim, as well as all lean, fat, bone, or other trimmings removed in making retail cuts.

EFFECT OF STILBESTROL ON BEEF CARCASS QUALITY AS MEASURED BY PHYSICAL AND CHEMICAL DETERMINATIONS. J. R. Stouffer, Sleeter Bull, B. C. Breidenstein, A. L. Neumann and W. W. Albert, *University of Illinois.*

Carcass studies were made on three lots of seven Hereford steers each which had been full-fed a fattening ration in dry lot. Two of the lots were fed 10 mg. of diethylstilbestrol per head daily. The steers in one of the stilbestrol lots were slaughtered at the same final weight as the controls, while the steers in the other stilbestrol lot were slaughtered after they had consumed the same total concentrates as those of the control lot. The steers in the silbestrol lot fed to the same weight as the check lot had a lower percentage of brisket and a higher percentage of rump than the other lots. The percentage of front quarter was lower and the percentage of hind quarter was higher in the stilbestrol lot to equal weight than in the control lot. The control lot had a higher percentage of ether extract in the *longissimus dorsi* muscle from the wholesale rib cut than either of the other lots. The stilbestrol lot fed to equal concentrate consumption as the check lot had a higher percentage of moisture in the *longissimus dorsi* muscle than the control lot. The carcass grades of the control lot tended to be higher than the other lots. There were no differences in drift, dressing percentage or cooler shrink. There were no differences in area of rib eye, in percentages of lean, fat, and bone of the wholesale rib cut, and in specific gravity of the wholesale rib cut between lots. Specific gravity had correlation coefficients of —0.86 with percentage of separable fat and —0.93 with ether extract of the wholesale rib cut.

CARCASS CHARACTERISTICS OF HEIFERS AS AFFECTED BY FEEDING AND IMPLANTING DIETHYLSTILBESTROL. B. C. Breidenstein, N. B. Webb, S. Bull, A. L. Neumann and W. W. Albert, *University of Illinois.*

Forty-eight Hereford heifer calves were divided into three lots of 16 each and placed on a full feed of grain for a total period of 194 days. One lot received oat silage as roughage while the other two lots received grass silage. One of the grass-

silage lots received 5 mg. of diethylstilbestrol orally per head per day. Treatment within lots consisted of implantations of diethylstilbestrol in the ear. Treatment A received no impants; treatment B received an implant of 40 mg. at the beginning of the test; treatment C received implants of 20 mg. at the beginning of the feeding period and every 28 days for the remainder of the time on feed; and treatment D received an implant of 40 mg. after 98 days on feed. After completion of the feeding period, the animals were slaughtered and carcass data were obtained. No significant differences, either among lots or among treatments, were shown with respect to live slaughter grade, udder weight, cooler shrink, dressing percentage, carcass grade, specific gravity of the wholesale rib, specific gravity of the rib eye muscle of the wholesale rib, percentage of eye muscle in the wholesale rib, percentage of bone in the wholesale rib, or subjective evaluation of marbling in the rib eye muscle. Highly significant differences in area of the rib eye were shown to exist between lots and between treatments. Significant differences in carcass grade on conformation were shown between lots.

SPLITTING AND CUTTING ERRORS IN SWINE CARCASS EVALUATION. E. L. Lasley and E. A. Kline, *Iowa State College.*

Splitting and cutting errors which arise in the process of cutting swine carcasses were studied by comparing left and right wholesale cuts from 222 barrows. The left carcass side averaged heavier than the right carcass side; produced the greater mean weight of loin, ham, picnic, picnic-plus-Boston butt, lean cuts and primal cuts; and the lesser weight of bacon and Boston butt. Mean loin eye area was greater for the right side whether measured at the 10th or last rib. Part of the difference for loin, picnic, Boston butt, lean cuts and primal cuts was caused by failure to split the carcass into halves of equal weight. The correlation between left and right wholesale cuts was computed as an indication of the magnitude of cutting errors. Highest correlation was observed for weight of ham followed by loin eye area, lean cuts, primal cuts, bacon, half carcass, loin, picnic, and Boston butt. The results of this study indicate that splitting and cutting errors may severely limit the reliability of estimates obtained by evaluation of a single carcass side.

PREDICTING LEAN CUTS FROM LIVE HOG AND EASILY MEASURED CARCASS TRAITS. E. L. Lasley, L. N. Hazel and E. A. Kline, *Iowa State College.*

All possible correlation coefficients were computed among shrunk (24 hour) liveweight, carcass weight, ham weight, loin weight, picnic weight, Boston butt weight, bacon weight, weight of 4 lean cuts, weight of 5 primal cuts, carcass length (front first rib to aitch bone), carcass backfat, backfat measured by live probe and loin eye area (10th rib) for 222 barrows. Carcass weight was more highly correlated with most traits than was shrunk liveweight due to greater part-whole constriction and the tendency for fatter barrows to yield heavier carcasses. Exceptions were found for ham weight and carcass length. The correlations of various traits with lean cuts were ham, .88; loin, .78; Boston butt, .73 loin eye area, .69; probe, —.57; picnic, .52; backfat, —.51; length, .38; and bacon, —.19. Squared multiple correlation coefficients of particular interest for predicting lean cuts were: (1) shrunk liveweight and probe, .44; (2) carcass weight, backfat and length, .50; (3) carcass weight, backfat and loin eye area, .69; (4) carcass weight, backfat, length and loin eye area, .70; (5) carcass weight and ham weight, .80; (6) carcass weight backfat and ham weight and ham weight, .82; and (7) carcass weight, backfat, length, loin eye area and ham weight, .91. It would be difficult to exceed the last value because weight of lean cuts is not estimated without error.

FAT CHARACTERISTICS OF FRESH AND AGED HAMS AND SHRINKAGE DURING AGING. James D. Kemp, Harry C. McCampbell and Robert B. Grainger, *University of Kentucky*.

Two methods of rendering small ham fat samples, (1) open-air rendering in oven and (2) vacuum rendering under nitrogen, were compared for their effect on subsequent iodine numbers, peroxide numbers and free fatty acid values of the rendered fat. Fat rendered with method (2) gave significantly lower peroxide values but showed no differences in iodine numbers or free fatty acid values. Hams from 43 hogs of similar known history were dry-cured, smoked, and aged for 6 months at 70° F. with a relative humidity of 50%. Fat samples were taken from each right ham when fresh, after curing, after smoking, and at monthly intervals during aging. There were no significant changes in iodine numbers during the period. Peroxide numbers increased during curing, decreased during smoking and were erratic during the aging process. Average free fatty acid values (as percent oleic) increased with each period as follows: fresh, .23; cured, .56; smoked, .96; 1 mo., 2.91; 2 mo., 4.68; 3 mo., 6.23; 4 mo., 7.58; 5 mo., 7.98; and 6 mo. 8.42. Fat from barrows was more saturated as shown by significantly lower iodine numbers. Sex had no effect on peroxide values or free fatty acid values. Free fatty acids developed faster in fat from hogs slaughtered from October through December than from hogs slaughtered from July through September. Average percent shrinkage for the hams after curing, smoking and each month during aging was 2.06, 8.61, 18.07, 22.31, 24.90, 27.22, 29.44, and 30.48, respectively.

CARCASS QUALITY CHARACTERISTICS OF MARKET BARROWS AND GILTS. O. J. Herbert and R. M. Crown, *Louisiana State University Experiment Station*.

Today's pork industry is faced with the all-important problem of producing a market hog that yields only a limited amount of uneconomical fat and a higher percentage of lean cuts. Since super-markets came into being with their self-service meat counters, pork must sell itself on the basis of quality and eye appeal. In recent years, considerable attention has been given to carcass and meat evaluation of hogs. Live hog and carcass measurements have been studied to determine their accuracy in depicting the lean meat yield in pork carcasses. The animals used in this study were purebred Duroc hogs from experimental breeding trials conducted at Louisiana State University Experiment Station. This experiment was designed to compare the carcass quality characteristics of market barrows to those of gilts. An analysis of the data shows that gilt carcasses yielded a higher percentage of ham, higher percentage of loin, larger planimeter area of loin and a higher percentage of separable lean in hams than did the barrows. These differences were found to be highly significant. The thickness of lean in hams was significantly greater in gilts than those in barrows. The average back fat thickness of barrows was highly significantly greater than that of gilts. The percentage of separable fat in the hams of barrows was significantly greater than that in gilts. No significant difference was found in the percentage of separable bone in hams of barrows and gilts.

EFFECT OF CHLORTETRACYCLINE ON CARCASS YIELDS INCLUDING PHYSICAL AND CHEMICAL COMPOSITION OF DAIRY CALVES. F. T. Landagora, L. L. Rusoff, B. Harris, Jr., R. M. Crown and J. E. Bertrand, *Louisiana Agricultural Experiment Station*.

Fifty-four newborn Holstein and Jersey dairy calves were divided at random according to breed into three comparable groups. One group served as the control,

another was fed 50–75 mg. chlortetracycline daily while the third was administered 400 mg. weekly by muscular injection. The experimental period lasted 12 or 16 weeks. Chlortetracycline administration to dairy calves increased growth rate and feed utilization efficiency significantly ($P<.01$) more than the controls at the slaughter dates, 12 and 16 weeks of age. The cuts of highest value in the veal carcass such as the round (with shank and rump on) and the rib sections were increased in size and weight in the antibiotic-treated groups over control calves. Using the planimeter area of the eye muscle (L. dorsus) as an indication of amount of muscular tissue, carcasses from antibiotic-treated calves showed a higher meat yield than those from calves fed no antibiotic. Tenderness as measured by the shearing strength of the 12th rib eye muscle was unaffected by chlortetracycline feeding to dairy calves. There was a good indication that oral feeding of chlortetracycline had increased carcass fat deposition whereas the parenteral administration enhanced protein synthesis. Based on the physical characteristics of the 12th rib, the data indicated that the effect of chloretetracycline upon the carcass of dairy calves was due to an over-all increase in body weight and not to a particular component, bone or muscular tissue. There was no significant difference in bone or meat percentages among treatments whereas weights of bone and meat were significantly heavier in the antibiotic-treated calves as compared to the controls.

AN AIR DISPLACEMENT METHOD FOR DETERMINING SPECIFIC GRAVITY, J. A. Liuzzo, E. P. Reineke and A. M. Pearson, *Michigan State University*.

A method has been developed for determination of the body volume of intact living animals by the amount of air that they displace. Specific gravity is obtained by dividing the animal's weight by its volume. The apparatus devised consists of two chambers of approximately 2600 ml. capacity connected to each other and to a Mercury Manometer and vacuum pump by a suitable arrangement of stopcocks. Temperatures in the chambers are measured with thermistors and determinations are performed in air saturated with water vapor to avoid changes in vapor pressure. A partial vacuum is drawn in the standard chamber and the pressure recorded. The stopcock leading to the animal chamber is opened, resulting in a rise in pressure that is proportional to the ratio between the volume of the animal chamber and the standard chamber. Animal volume is determined by subtracting the volume of the chamber with the animal in it from the volume of the empty chamber. Specific gravity determinations were made by air displacement on 23 adult female guinea pigs weighing 507–1064 gm. The animals were then sacrificed and specific gravity of the eviscerated carcass was determined by water displacement. Live specific gravity ranged from 1.0632 to 1.1918. Specific gravity of the carcasses ranged from 1.0261 to 1.0926. The correlation between the two methods was 0.742, significant at the 1% level. Data on the relation between specific gravity and carcass fat content will be presented.

A COMPARISON OF THE LIVE PROBE AND LEAN METER FOR PREDICTING CARCASS MEASUREMENTS OF SWINE. A. M. Pearson, J. F. Price, L. J. Bratzler, W. T. Magee and J. A. Hoefer, *Michigan State University*.

Correlation coefficients were calculated on slaughter data obtained from a total of 99 hogs probed with both the lean meter and live probe at the same sites. The relationship between the live probe and lean meter was +.78, indicating that only 61% of the variability between measures could be accounted for by a

corresponding variation in the other measurement. Other relationships for live probe and lean meter values, respectively, were +.11 and +.21 for dressing percentage, −.38 and −.28 for carcass length, +.70 and +.71 for backfat thickness, −.62 and −.60 for lean cuts-live basis, −.67 and −.68 for lean cuts-carcass basis, −.61 and −.57 for primal cuts-live basis, −.47 and −.54 for primal cuts-carcass basis, −.56 and −.53 for specific gravity for the ham, −.49 and −.28 for lean area of the loin at the last rib, −.58 and −.40 for loin lean area at the 10th rib, and +.67 and +.52 for fat trim. Thus, results indicate there is little difference in the usefulness of either the live probe or the lean meter in regard to the carcass cut-outs. However, the higher relationship for the live probe with specific gravity, with both loin lean areas and fat trim indicates the live probe to be the more reliable measure.

SPECIFIC GRAVITY AND CHEMICAL COMPOSITION OF THE UNTRIMMED HAM AS RELATED TO LEANNESS OF PORK CARCASSES. J. F. Price, A. M. Pearson and E. J. Benne, *Michigan State University.*

Cut-out, specific gravity, chemical analysis and other data were collected from 36 hog carcasses and correlation coefficients were calculated between various measures for leanness. The specific gravity of the untrimmed ham was closely related to specific gravity of the carcass (+.86), and both specific gravity values were closely associated with chemical composition, cut-out percentages and loin lean area. Specific gravity was more closely related to chemical composition and loin lean area than any other measure, indicating that specific gravity more nearly measured muscling *per se* than any other factor studied. However, backfat thickness and live probe more closely predicted cut-out. Carcass length was not significantly related to cut-out values, chemical composition or exterior fat thickness. Multiple correlation coefficients in which carcass length was combined with either backfat thickness or live probe gave little advantage over the use of either measure taken alone. Dressing percentage was not significantly related to specific gravity or lean area of the loin. The lean area of the loin as measured at the tenth rib more closely predicted cut-out values than the same area measured at the last rib.

DIFFERENTIAL TISSUE DEVELOPMENT IN HAMS DURING GROWTH OF SWINE. D. E. Brady, S. E. Zobrisky and A. M. Mullins, *University of Missouri.*

During the growth period studied, the live animal carcass and ham weight increased in a linear manner. The specific gravity was found to decrease with an increase in ham weight indicating a greater percentage of fat in the heavier hams. This was verified by linear measurements and physical dissection. The fatty tissues increased at an accelerated rate from 50 to 300 lb. live weight. Whereas the lean, bone and tendons in the ham increased at a declining rate during this weight interval. During the growth interval from 50 to 100 lb. (1:2 ratio) in live weight, the fatty tissues increased at a rate of 1:3.25, while the lean tissue increase was proportional to the live weight. When comparing the increase in live weight to the weight increase of the fat and lean tissues from 50 to 200 lb. (1:4 ratio) these tissues increased at a rate of 1:7.25 and 1:3.25 respectively. When the same comparisons are made between the 50 and 300 lb. live weight (1:6 ratio) the fat increased at a rate of 1:14 with the lean increasing at a rate of 1:4.5. To be presented are the analyzed data for the component tissues from more than 100

carcasses. Complete dissection of the various ham tissues, linear and areal measurements as well as specific gravity determination have been used extensively in determining the various correlation and estimating equations.

THE EFFECT OF CERTAIN ESTROGENIC COMPOUNDS ON CARCASS CHARACTERISTICS OF FEEDER LAMBS. R. J. Davey, G. H. Wellington and J. P. Willman, *Cornell University*.

The effects of various hormone treatments on carcass characteristics of western feeder lambs have been studied in two trial using 21 lots of 12 lambs per lot. The basal rations for both trials contained either corn, cooked Red Kidney beans or a combination of the two, linseed meal, legume hay and corn silage. The hormone treatments for the first trial of 91 days were (1) control, (2) implants of 100 mg. progesterone—10 mg. estradiol per lamb, and (3) feeding 5 mg. of stilbestrol per lamb per day for the first 58 days and 2.5 mg. for the remainder of the feeding period. In the second trial of 103 days the treatments were (1) control, (2) feeding 5 mg. stilbestrol per lamb per day for the first 54 days of the trial and 1 mg. for the remainder, (3) feeding 5 mg. stilbestrol for 54 days and no hormone for the remainder, and (4) feeding 5 mg. benzestrol for 54 days and 1 mg. for the last part of the test. Live grades for lambs in the first trial were significantly lower for hormone-treated lots (control, 5.85; progesterone-estradiol, 5.03 and stilbestrol, 4.50). Carcass grades followed the same trend (6.03, 5.69, and 4.83). In the second trial the grades did not show as much variation, the lambs not being carried to as high a degree of finish, but both live and carcass grades for lambs getting stilbestrol continuously were slightly lower than those for other lots. Chemical analyses of the meat from the 9-rib racks of three lambs in each lot showed a slightly higher moisture and protein, and lower fat percentage for treated lambs.

ESTROGENIC RESIDUES IN CARCASSES OF FEEDER LAMBS TREATED WITH VARIOUS HORMONES. David T. Armstrong and William Hansel, *Cornell University*.

The estrogenic potencies of various tissues from lambs treated with natural and synthetic sex hormones were determined using a 72-hour immature rat uterine weight test method. The studies were conducted over two seasons, and involved 21 lots of 12 lambs per lot. The assays were run on composite samples of each tissue obtained from 3 lambs in each lot. In the 1954–1955 trial measurable amounts of estrogenic activity expressed as stilbestrol equivalent per kg. of tissue were found in ether extracts of fat from lambs in the various lots as follows: Stilbestrol fed at the rate of 5 mg. per day for 58 days and 2.5 mg. per day for 33 days, 61 mcg. per kg.; estradiol (10 mg.) and progesterone (100 mg.) implanted, 46 mcg. per kg.; and untreated, 51 mcg. per kg. The fat from the stilbestrol-fed lambs contained significantly more estrogenic activity than the fat from the control lambs. Lean from the estradiol- and progesterone-implanted lambs contained 8 μg stilbestrol equivalent per kg. of tissue. In the 1955–1956 trial measurable amounts of estrogenic activity were detected in ether extracts of 9-rib racks from lambs fed stilbestrol at the rate of 5 mg. per day for 54 days and 1.0 mg. per day for 46 days (4 mcg. per kg.), and from lambs fed benzestrol at the same rate (4 mcg. per kg.). No measurable activity was found in similar extracts from the untreated lambs or from lambs removed from stilbestrol feeding 46 days prior to slaughter.

MEASUREMENTS OF INTRAMUSCULAR FAT, MYOGLOBIN AND HEMOGLOBIN CONTENT OF BEEF RIBEYE MUSCLE FROM ANIMALS FED SEVERAL COMBINATIONS OF GRASS AND GRAIN. H. B. Craig and T. N. Blumer, *North Carolina State College.*

Studies were made to determine the effect of pasture feeding on the fat content, color of external fat, color and storage qualities of lean. Sixty grade Hereford steers were divided into lots of ten each. Lot I received pasture only; Lot II pasture and grain—0.5% of body weight; Lot III pasture and grain—1.0% of body weight with 10% beef tallow; Lot IV same as Lot III with no fat; Lot V pasture and grain (deferred)—1.5% body weight and Lot VI an all grain ration in dry lot. Intramuscular fat deposits (marbling) in the twelfth rib cross section of the ribeye muscle were measured in square millimeters. The average respective lot values were 190.92, 198.82, 183.47, 235.32, 205.45 and 283.30. Correlations between measured fat—numerical grade and measured fat—ether extract were significant and highly significant respectively. Total pigment and myoglobin values were determined spectrophotometrically from muscle extracts. The animals of Lots II and III had a significantly higher myoglobin content than those of Lot VI. Myoglobin values were determined for each individual sample and the hemoglobin content determined by difference. Visual color of the ribeye was read on a Hunter Color Difference Meter and the readings converted to Munsell notations. These values were related to pigment content in that those samples having more pigment also had more intense color. Color stability of the ribeye after 7 days storage at 34° F. was determined and the results analyzed by lots.

FASTING EFFECTS ON DRESSED YIELD, SHRINKAGE, AND pH OF CONTRACTILE. J. W. Cole, R. L. Saffle and C. S. Hobbs, *University of Tennessee.*

Eighty-eight market hogs representing thirteen litters were fasted for 0, 24, 48, 72 and 96 hours to observe shrinkage effects on various tissues. Pigs (full sibs) were selected at random within litters to be killed at the various time intervals. Using standard or accepted techniques, data were obtained on various carcass measurements, cutting percentages, offal percentages, and pH of both the fresh and the cured ham. Differences between dressing percentages on a within litter basis among the various shrinkage times were not significant, although dressing percentage tended to decrease with an increase in shrinkage time from 0 to 96 hours. The liver was significantly lowered in percentage yield based on off-feed weights. Significant differences were noted between various portions of both the full and empty viscera with time off feed. A highly significant positive correlation of .495 was observed between backfat thickness and dressing percentage. The percentage of primal cuts, cutting fat as well as other fats was not affected by the four day shrinkage period. The pH of both fresh and cured pork muscle was not altered by the fasting regime. Additional data which do not support presently accepted theories concerning tissue shrinkage will be reported.

A STUDY OF FACTORS ASSOCIATED WITH MERIT IN SWINE CARCASSES AND PORK CUTS. H. L. Self, R. W. Bray and R. J. Reierson, *University of Wisconsin.*

One hundred fifty U.S. No. 1, 150 U.S. No. 2, 150 U.S. No. 3 and 134 medium grade pork carcasses were selected into six 7 lb. weight ranges: 126–132 (1), 133–139 (2), 140–146 (3), 147–153 (4), 154–160 (5) and 161–167 (6). Only 9 carcasses were included in the medium grade of weight range 6. Both sides of

the carcass were divided into the standard primal wholesale cuts, weighed and the ham and loin of the left side graded. The percent ham and loin respectively by grades was: U.S. No. 1—19.4 and 15.4; U.S. No. 2—18.3 and 14.6; U.S. No. 3—17.2 and 13.6; medium 20.2 and 16.0 Grade 1 hams and grade 1 loins were yielded by 72 and 39% of the US. No. 1 carcasses respectively; 66 and 19% of U.S. No. 2 carcasses; 65 and 14% of the U.S. No. 3 carcasses and 31 and 39% of the medium carcasses. Grade 2 hams and loins were yielded by 27 and 47% of the U.S. No. 1 carcasses; 25 and 57% of the U.S. No. 2 carcasses; 17 and 53% of the U.S. No. 3 carcasses; and 68 and 28% of the medium carcasses. Grade 3 hams and loins were yielded by 1.3 and 7.0% of the U.S. No. 1 carcasses; 9.3 and 21% of U.S. No. 2 carcasses; 17 and 33% of the U.S. No. 3 carcasses and 1.3 and 39% of the medium carcasses. A medium grade loin was produced by 6% of the U.S. No. 1, 3% of the U.S. No. 2; 1% of the U.S. No. 3 and 5% of the medium carcasses. Average carcass length, average back fat and average square inches of loin eye respectively for U.S. No. 1, were 29.4, 150 and 3.92; for U.S. No. 2, 28.7, 1.77 and 3.60; for U.S. No. 3, 27.9, 2.04 and 3.27; for medium 30.3, 1.30 and 4.0. The percent lean cuts were 50.5, 47.5, 44.5 and 52.5 for the four carcass grades respectively.

Pastures and Forages Section

D. M. BAIRD, *Chairman*

CELLULOSE CONTENT OF THE LEAVES AND STEMS OF SEVERAL GRASSES AND RELATION OF SEASON TO CELLULOSE DIGESTIBILITY BY CATTLE. W. Brady Anthony, W. R. Langford and J. G. Starling, *Agricultural Experiment Station of the Alabama Polytechnic Institute.*

Seasonal changes were measured in contents of cellulose and protein and digestibility of cellulose in whole plants and in leaves and stems of Coastal and common Bermudagrass, and Pensacola Bahiagrass. Cellulose content in whole plants was similar for all three grasses, and unlike crude protein, was not affected by applications of nitrogen fertilizer; it only slightly increased as the growing season advanced. Cellulose contents were almost the same for leaves and stems, and, therefore, it does not appear that cattle could selectively graze material either high or low in cellulose. There was a wide difference in the concentration of protein in leaves and stems. Since cellulose was equally distributed throughout the plant, chemical analyses of clipped samples of forage provided a measure of cellulose in forage consumed by grazing steers; indigestible cellulose was determined through the use of excretion data provided by application of the chromic oxide indicator method. There was little difference in cellulose digestibility among the 3 forages. Cellulose was slightly more digestible in the early spring, but the seasonal decline in digestibility was not great. Cellulose and crude protein concentrations in leaves and stems of some grasses and legumes clipped from other locations were measured. For the legumes, cellulose was considerably lower and protein considerably higher in leaves than in the stems. In the grass group, leaf cellulose concentration was about the same as stem cellulose, but leaf protein was much greater than stem protein.

A COMPARISON BETWEEN NUTRIENTS AVAILABLE AND NUTRIENTS CONSUMED BY GRAZING SHEEP AS DETERMINED BY CHEMICAL ANALYSIS OF HAND-CLIPPED VERSUS ESOPHAGEAL FISTULA SAMPLES. Donald T. Torell and William C. Weir, *University of California.*

Range forage for chemical analyses was collected by hand clipping and by duplicate collections with esophageal fistulated wethers. An enclosure 100 by 100 feet was sampled nine times during the 1955 growing season. The hand-clipped samples are believed to represent the forage available while the esophageal fistula samples indicate the forage actually consumed by the sheep. The differences in chemical composition of the samples collected by the two methods are most clear cut in the crude protein fraction and the crude fiber fraction. Throughout the year—January through December—the crude protein content of the feed consumed was from 15 to 46% higher than that in the hand-clipped samples. The crude fiber content of the feed consumed was from 0 to 49% lower than that in the clipped samples. Nitrogen-free extract, ether extract, and silica-free ash did not show as marked a difference as the crude protein and fiber. It appears that sheep are selective in their grazing habits and graze those species or parts of plants which are higher in protein and lower in crude fiber than the plant population.

EFFECT OF STAGE OF MATURITY ON THE FEEDING VALUE OF ALFALFA AND OAT FORAGE. J. H. Meyer, W. C. Weir, L. G. Jones and J. L. Hull, *University of California.*

Oat and alfalfa forage were harvested in replicates from the same field at various stages of maturity and fed as a dehydrated, pelleted hay to growing sheep. The sheep were fed individually. Latin square designed digestion trials were also conducted on the hays. The oat hay was harvested at: (1) 59% jointing, (2) 16% flag leaf, (3) 21% boot, (4) 1% flower, (5) 18% flower, (6) 44% milk, and (7) 42% dough stage. Lignin, TDN (dry basis) and weighted daily gains (based on equivalent feed consumption) were respectively: (1) 3.8, 68, 0.26; (2) 4.3, 65, 0.24; (3) 4.9, 65, 0.22; (4) 5.8, 64, 0.21; (5) 6.4, 60, 0.23; (6) 9.0, 50, 0.12; and (7) 8.4, 53, 0.14. The highest nutritive value was found in the jointing stage but the greatest production of nutrients per acre was from the 18% flower stage. The milk stage was lowest in feeding quality. In the other experiment alfalfa was harvested at (1) pre-bud, (2) 1% bud, (3) 62% bud, (4) 11% bloom, (5) 46% bloom, (6) 96% bloom. The lignin content, TDN (dry basis) and weighted daily gains were (1) 5.3, 66, 0.33; (2) 6.4, 62, 0.28; (3) 6.6, 59, 0.27; (4) 8.2, 57, 0.22; (5) 8.2, 55, 0.23; (6) 8.3, 56, 0.22. The pre-bud and bud stage hays were highest in nutritive value but the greatest nutrient production per acre as measured by TDN and weight gains was from the bloom stages. An experiment currently in progress will be reported in which alfalfa harvested at various stages of growth is being fed as pelleted and chopped hay.

THE RESPONSE OF RUMEN MICROORGANISMS TO PASTURE GRASSES AND PRICKLY PEAR CACTUS FOLLOWING FOLIAR APPLICATION OF UREA. I. J. Belasco, M. F. Gribbins and D. W. Kolterman, *E. I. du Pont de Nemours & Co., Inc.*

In vitro rumen evaluations have shown marked improvement in cellulose digestion rates of pasture grass and prickly pear cactus which have received foliar application of urea solutions. The improvement cannot be explained solely

on the basis of the increased total nitrogen content. The increase in microbial cellulolytic response is indicative of improved nutritional quality of the grass and cactus resulting from this treatment. The rapidity of urea absorption and conversion coupled with the *in vitro* findings point to stimulation of plant growth processes resulting in alteration and improvement of the nutrient make-up of the plant. The nutritional, economic, timing and rapid response features make this mode of urea application attractive from a practical view-point. Applicability of this technique to other forage and food crops is indicated.

THE EFFECTS OF PASTURES AND ENVIRONMENTAL CONDITIONS ON NUMBERS OF INFECTIVE ROUNDWORM LARVAE AVAILABLE TO GRAZING CATTLE. W. N. Smith, H. H. Vegors, O. E. Sell and D. M. Baird, *Georgia Experiment Station, and Animal Disease and Parasite Research Branch, ARS, U.S.D.A.*

During the winters of 1954 and 1955 studies were conducted on the effects of type of winter pasture, low-level phenothiazine feeding and seasonal climatic factors on the number of infective roundworm parasite larvae available to grazing beef cattle and on the gains of these cattle. The pastures used were: 1. Oats, ryegrass and crimson clover, 2. Ryegrass, 3. Crimson clover on Bermuda grass sod, and 4. Fescue. Pastures 1 and 2 were plowed and seeded each fall. The last two were on permanent sod. Phenothiazine was fed ad-lib by incorporation of one part in mineral block or loose mixture of 3 parts each: salt, bonemeal, and limestone. Average number of parasitic larvae recovered from grass clippings were 23 and 12 per lb. green forage for temporary and permanent pastures with phenothiazine feeding, and 34 and 129 per lb. forage without phenothiazine feeding. The daily intake of phenothiazine was variable between pasture types averaging 2.23 gm. per calf on the permanent and 1.44 gm. on the temporary pastures. Phenothiazine was most effective in reducing larvae on crimson clover and fescue and was variable in its effect from slight to no control on temporary and ryegrass. With a relatively low level of parasitism of all animals, the nutritional adequacy of the forage appeared to influence cattle gains more than did usual anthelmintic or larvacidal action of phenothiazine. Change in environmental conditions from winter to spring apparently resulted in a rapid increase in the number of larvae on pastures the first year but no marked increase was noted the second year due to prolonged cool weather.

EARLY WEANING OF LAMBS ON HIGH QUALITY PASTURES. D. M. Baird and O. E. Sell, *Georgia Experiment Station.*

Grazing and nursing habit studies made on ewes and their lambs indicated that when the lambs weighed approximately 70 lb. their nursing was generally infrequent and some individuals had already been weaned. These lambs were grazed on excellent winter temporary forages consisting of oats, rye, ryegrass and crimson clover. The conserve this forage and reduce the breeding flock's pasture cost, a two year study has been made on the early weaning of lambs. The lambs were weaned at an average wt. of 70 lb. the first year and at an average wt. of 60 lb. the second year. All lambs were on experiment to 90 lb. before marketing. The treatments and A.D.G. for the first year were: Lot 1, Pasture, weaned at 90 lb., .63 lb.; Lot 2, Pasture + creep, weaned at 90 lb., .63 lb.; Lot 3, Pasture, weaned at 70 lb. and start grain feeding, 56 lb. The treatments and A.D.G. for the second year were: Lot 1, Pasture only, weaned at 90 lb., .53 lb.; Lot 2, Pasture only, weaned at 60 lb., .57 lb.; Lot 3, Pasture + creep, weaned at 90 lb., .53 lb.; Lot 4, Pasture + creep, weaned at 60 lb., .55 lb. Early weaning had no detrimental effect on rate of gain or market grade nor was grain

creep consumption increased following early weaning. On excellent winter pasture it appears that lambs can be successfully weaned before reaching market weights, thus reducing the total flock pasture cost.

THE USE OF LIMITED QUANTITIES OF HIGH QUALITY FORAGE TO IMPROVE PERSISTENCY OF MILK PRODUCTION. M. E. McCullough and O. E. Sell, *Georgia Experiment Station.*

Two feeding and digestion trials were conducted to determine the effect of 2 hours grazing on a winter pasture (largely oats and ryegrass) on persistency of milk production. The 1954 trial compared a ration of 50. lb. corn silage, 10 lb. lespedeza hay and grain 1:4 with a similar ration in which 2.4 lb. dry matter from pasture forage replaced the grain. The grain group required 75.85 lb. TDN per 100 lb. 4% milk and had a persistency of 96% for a 30-day period. The comparable values for the pasture group were 54.78 lb. TDN and 113% persistency. The 1955 trial compared similar rations with alfalfa hay substituted for lespedeza. The corresponding values were: grain group, 81.49 lb. TDN per 100 lb. milk and 94% persistency; 2 hr. of grazing (5.8 lb. forage dry matter daily), 72.89 lb. TDN and 112% persistency. A third group was included in which 5% of the grain ration was composed of grass juice. The grass juice resulted in no improvement over the regular grain ration in either feed efficiency or persistency of milk production. In both years the cows in the pasture group increased slightly in body weight. The increased persistency of milk production apparently cannot be explained on the basis of an increased intake of TDN.

EFFECTS OF STILBESTROL IMPLANTED IN BEEF CATTLE ON PASTURE. C. C. O'Mary, J. L. Carmon and A. E. Cullison, *University of Georgia.*

Forty steers averaging 475 lb. were weighed and placed on pasture. After 56 days the steers were weighed again and on the basis of their rates of gain were divided into a high and a low gaining group (1.93 and 1.10 lb. per head daily, respectively) with a random half of each group being implanted with 24 mg. of stilbestrol per animal. Forty-two days after stilbestrol treatment the rates of gain were, for the low gaining control group, .99 lb.; high gaining control, 1.07, lb.; low gaining stilbestrol treated, 1.58 lb. and high gaining stilbestrol, 1.58 lb. The increased gains as a result of stilbestrol treatment were highly significant. The difference between the low and high gaining groups was not significant. Further analyses were made at 70, 99 and 114 days after treatment. At 70 days the difference in rate of gain in favor of the hormone treated steers approached significance. At 99 days the effect of the hormone treatment was significant and a difference approaching significance was found between the high and low gaining groups. Over a period of 114 days the daily gains were 1.02, 1.37, and 1.38 and 1.54 lb. respectively for the above named groups. The average daily increase in favor of the stilbestrol treated steers over the control was .26 lb. which was significant. A significant difference of .25 lb. per head daily was found in favor of the high gaining group over the low gaining group. There was no significant gaining roup hormone treatment interaction at any time.

THE EFFECTS OF RATE OF FERTILIZER APPLICATION ON PANGOLA GRASS PASTURES AS MEASURED BY GRAZING BEEF CATTLE. L. H. Horn, Jr. and C. V. Ross, *Swift & Company.*

A two-year study involving two winter grazing trials with two groups of yearling steers grazing irrigated Pangola grass pasture treated with varying levels of 8–8–8 fertilizer has been completed. The experiment was conducted on sandy

soil in South Central Florida. Protein and dry matter analyses were made monthly throughout the experiment. Returns from the pastures were measured by daily gains, gains per acre, and gross returns above cost of fertilizer. The fertilizer was applied in equal quantities in the late Fall and early Spring with the total annual treatments being 0, 400, 600, 800, 1000, and 1200 lb. per acre. Average daily gains for the two 7-month winter grazing studies ranged from a low of 0.80 lb. per head for the controls to a high of 1.33 lb. for the most heavily treated pasture. The daily gains in both trials increased consistently as the levels of fertilizer were increased even though the pastures were stocked to provide equal quantities of forage on all pastures throughout the experiments. The average rate of stocking ranged from a low of 0.62 steer per acre for the controls to a high of 1.31 head per acre for the most heavily fertilized pasture. Carcass grade and yield and protein content of the forage increased progressively with rate of treatment.

PERMANENT BLUEGRASS PASTURES WITH AND WITHOUT BIRDSFOOT TREFOIL. W. M. McVey and G. O. Mott, *Purdue University*.

Hereford yearling steers were used each year during a seven year period to compare permanent bluegrass pastures. The pastures were treated uniformly with lime, phosphate and potash during the seven year period. The basic fertility treatment consisted of liming to a pH of 6.5 and six annual applications each of 300 lb. per acre of an 0–20–10 fertilizer. The following three treatments on bluegrass were studied; 1. bluegrass alone, 2. bluegrass plus birdsfoot trefoil and 3. bluegrass plus 120 lb. of nitrogen applied annually in a split application. The three treatments produced about the same average daily gain on steers; 1.06, 1.12, and 1.13 lb. respectively. The carrying capacity in terms of steer days per acre was quite different for the three treatments; 187, 273 and 302 steer days. The mixture of birdsfoot trefoil-bluegrass produced 341 lb. of beef per acre compared with 196 lb. without the birdsfoot trefoil. The application of 120 lb. of nitrogen per acre increased the production of bluegrass alone to 306 lb. of beef per acre. This increase however, did not equal the production from the birdsfoot trefoil-bluegrass mixture.

PRODUCTION OF BEEF FROM PASTURE AS INFLUENCED BY LEVEL OF WINTER FEEDING. G. O. Mott, W. M. McVey and H. N. Wheaton, *Purdue University*.

Hereford steer calves were purchased in the fall of 1952, 53 and 54 for use in grazing trials the following growing season. The steers were sorted for uniformity and divided into four wintering groups. Group I was fed a ration to produce gains of 0.5 lb. daily; Group II, 1.0 lb.; Group III, 1.5 lb.; and Group IV, 2.0 lb. The rations fed consisted principally of different combinations and amounts of corn silage, ground corn cobs, and Purdue supplement A. Representative steers from each of these groups were used to measure the (a) carrying capacity as indicated by the number of steer days per acre, (b) average daily gain per steer, and (c) beef gain per acre on several pastures. Two pasture mixtures, alfalfa-ladino clover-bromegrass, and birdsfoot trefoil-bluegrass were measured in three field replications during the three year period, 1953, 54 and 55. The alfalfa-ladino clover-bromegrass pasture had carrying capacity of 292, 278, 275 and 266 steer days per acre for steers wintered to gain at .5, 1.0, 1.5 and 2.0 lb. rates respectively. For the same groups of steers and the same forage mixture the average daily

gains were 1.51, 1.41, 1.06 and .98 and beef gains per acre were 425, 386, 282 and 259 lb. The birdsfoot trefoil-bluegrass pasture carried 344, 344, 326 and 319 steer days per acre for the four wintering levels respectively. The average daily gains were 1.14, .99, .80 and .64 and the beef gains per acre were 392, 336, 252 and 203 lb. In pasture experiments the level of winter feeding has little effect upon the number of animals which the pasture will carry but has a great influence on the average daily gains and consequently upon the beef gain per acre.

A COMPARISON OF TWO CHEMICAL PRESERVATIVES FOR GRASS SILAGE. R. S. Allen, C. F. Foreman and A. R. Porter, *Iowa State College.*

Approximately 480 tons of first-cutting non-wilted, chopped forage (alfalfa with some bromegrass) were ensiled in a bunker silo (24×100 foot concrete base, 4 foot concrete walls on two sides). Sodium metabisulfite (8 lb. per ton) was added by hand broadcasting to the forage (just prior to packing with a tractor) in a quarter segment (12×50 feet) of the silo. An adjacent segment (12×50 feet) had no preservative added. In a third segment Kylage (5 lb. per ton) was added by broadcasting. The fourth segment, adjacent to the Kylage quarter, contained no preservative. Care was taken to get good distribution of the preservative and to avoid undue overlapping of preservative into the non-preserved area. Ten sample (three depths) of the forage at the time of ensiling were taken from each quarter segment. At the time of sampling, a muslin bag was filled with the same material and left at various locations in the silo. These bags were removed during the feeding operation in the fall and winter months. Chemical analyses of the forage as ensiled revealed minor differences which were attributed to the ratio of alfalfa to grass. Silages with preservatives added tended to have slightly lower pH values and crude protein content, slightly higher dry matter content, and definitely lower ammonia nitrogen values. All silages were consumed readily. Limited data indicated that dry cows preferred non-treated to Kylage-treated silage when silages were the only feeds offered. However, when silages, concentrates and fresh straw were available, the cows showed no preference for either type of silage.

CHROMOGEN AND PROTEIN EXCRETION BY WETHERS GRAZING FESCUE AND LADINO-ALFALFA PASTURES. Neil Bradley, Patch G. Woolfolk, Noel Stephens, R. B. Grainger and W. C. Templeton, *University of Kentucky.*

Six yearling wethers grazing Ladino-alfalfa and six grazing fescue were used in a digestibility indicator study in which variability of chromogen and protein excretion was determined. The protein and chromogen excretion curves resulting from samples taken four times daily for five days showed a great degree of variation with no special pattern. Average 1-day excretion curves showed considerably less variation, but exhibited no similar concentration-time pattern. Digestion coefficients as determined by the chromogen technique from composite samples representing either 6 a.m., 12 noon, 6 p.m., or 12 midnight collections were not significantly different from average digestion coefficients representing a total 5-day collection. The use of Reid's formula for determining forage chromogen units resulted in lower and seemingly more accurate digestion coefficients than the use of forage units from oxalated extracts of hand-sampled forage. Results indicate that reliable digestion coefficients may be determined by the chromogen technique when a composite sample representing 5 or more samples taken over a 5-day period is used. Time of day apparently is not of much importance in sampling for chromogen and protein when sheep are used.

AN EVALUATION OF CORN COBS AS A PARTIAL ROUGHAGE FOR LACTATING DAIRY COWS. C. A. Lassiter, C. F. Huffman and C. W. Duncan, *Michigan State University.*

Fifteen lactating Holstein cows were used in five 3×3 latin square designs with each period 27 days in length to compare corn cobs with a 2nd cutting alfalfa-brome grass hay as a source of roughage. Group 1 received 25 lb. of hay daily, Group 2, 17 lb. hay and 8 lb. of ground corn cobs and Group 3, 9 lb. hay and 16 lb. of corn cobs. All cows were fed a 20.8% crude protein grain mix at a rate to supply Morrison's minimum TDN standards. An excessive amount of protein was fed to all cows. The hay contained 47.8% TDN. Digestion trials were conducted with 7 cows receiving comparable amounts of feed using chromic oxide as the indicator. No significant differences existed between groups in the average daily production of 4% FCM body weight changes or butterfat test. The average production of 4% FCM for the last 6 days of each period was 32.6, 34.3 and 33.7 lb. for Groups 1, 2 and 3, respectively. No significant differences existed between groups in the coefficients of digestibility for dry matter and crude fiber. Group 1 cows had significantly higher (5%) coefficients of crude protein and nitrogen-free extract digestibility than Groups 2 or 3 and the coefficients for Groups 3 were significantly higher (5%) than Groups 1 or 2 for ether extract digestion. No significant differences in feed consumption existed. Results of this study indicate that ground corn cobs can be a satisfactory roughage for milking cows when properly supplemented.

GAMMA IRRADIATION AS A METHOD OF FORAGE PRESERVATION. J. R. Schubert, P. H. Weswig and C. M. Gilmour, *Oregon Agricultural Experiment Station.*

Four series of laboratory silos were prepared by a pressure canning technique using tall fescue from a single genetic source preserved with molasses at the rate of 70 lb. per ton. Fermentation of one series proceeded immediately to provide reference values. All other cans were frozen until further treatment. Two series were exposed to gamma radiation, one each at 250,000 and 3×10^6 rep, and the fourth series constituted a frozen control. Radiation treatments effected 99% and complete sterility, respectively, relative to a total plate count of 9.5×10^6 for the control. Irradiated forage underwent noticeable browning, but was not affected in terms of chemical criteria employed. Cans were then vented asceptically and incubated for biochemical characterization at intervals up to 12 weeks. Final results from the frozen control series (pH 4.15) were in good agreement with those from the unfrozen reference series (pH 4.16). Low level irradiation was followed by a restricted but dominantly nonvolatile acid fermentation (pH 4.48) with no change in soluble carbohydrate. Incubation following high level irradiation resulted in few changes associated with silage fermentation. Only non-protein nitrogen developed to the usual extent which was related to moderate increases in total acid and volatile base relative to an unchanged pH level (6.08) Increasing amounts of soluble carbohydrate were associated with decreased crude fiber. These changes apparently resulted from residual plant enzyme activity. It was concluded that ionizing radiation may be used as a means of study of ensiling processes, either exclusive of the microflora vector or with its repression.

EFFECTS OF ALFALFA SILAGE STORAGE METHODS IN FATTENING BEEF CATTLE. W. C. McCone, *South Dakota State College.*

Alfalfa silage was made through the wilting process without the use of preservatives. Methods of storage used were: an upright silo, a pile on the ground,

and a trench silo. An equal acreage of alfalfa as used in each silage source was baled as hay. Four lots of 10 yearling steers each were used in a feeding trial to determine beef production from the various methods of storing alfalfa. All of the alfalfa was weighed at the time of storage and again at the time of feeding. Chemical anlyses were made and moisture content taken at harvest time as well as through the entire feeding period. All cattle received equal amounts of corn in the ration with alfalfa. Average per head daily gains for all cattle were very similar in three trials; however, the total gain varied greatly due to the length of feeding periods which was 163 days for the upright silo, 95 days for the pile, and 111 days for the trench silo. Steers fed baled alfalfa hay made similar daily gains, and this source supplied feed for an equal length of time as the alfalfa silage in the upright silo. Necessary dry matter content of the alfalfa silage or hay at the time of storage to produce 100 lb. of beef was found to be 1220 lb. from the upright silo, 2339 lb. from the pile, 1740 lb. from the trench, and 1091 lb. from the hay.

INFLUENCE OF NITRATING AND/OR IRRIGATING BLUEGRASS-CLOVER PASTURES UPON PERFORMANCE OF YEARLING STEERS. H. R. Duncan, C. S. Hobbs, Hugh Felts and O. G. Hall, *University of Tennessee.*

Three pastures composed of bluegrass, white and hop clover with three replications each were set up as follows: (1) bluegrass, phosphated and potashed according to need based on soil tests, (2) same as (1) + an average of 336 lb. ammonium nitrate applied in 3 to 4 applications spread through grazing seasons, (3) same as (2) + application of an average of 8.6 in. irrigation applied as needed through season. Yearling steers were used and average daily gains of 1.32, 1.32 and 1.44 lb. were secured for 168 days. Grazing days per acre of 142.5, 188.1 and 298.6 were secured respectively. The accumulated beef gain per acre through the six 28 day periods were: 201.2, 268.3 and 424.1 lb. Extra steers were put on and taken off in order to utilize the forage and keep pastures as uniform as possible. There was little difference in the slaughter grade at the end of the grazing season. During the four years in which these trials were conducted the market was in a declining cycle and the steers were appraised about $4.25 higher in the spring than at the end of the grazing season. The gross returns from pasture per acre were therefore low being: (1) $9.16, (2) 15.73 and (3) 37.37. The average annual acre charges for fertilizer (at cost) and irrigation ($4.00 acre inch) were: $3.90, 20.96 and 55.36. The net acre-pasture returns over fertilizer and irrigation were therefore: $5.26, —5.23 and —17.99 respectively. The clovers disappeared in the No. 2 pastures which were nitrated. Irrigation with nitration as in No. 3. stimulated the growth of clovers.

EVALUATION OF ORCHARDGRASS-LADINO CLOVER, ORCHARDGRASS-FESCUE-LADINO, FESCUE-LADINO AND NITRATED FESCUE-LADINO PASTURES FOR THE PRODUCTION OF SLAUGHTER YEARLINGS. C. S. Hobbs, H. R. Duncan, Lawson Safley and O. G. Hall, *University of Tennessee.*

The orchardgrass-Ladino clover, orchardgrass-fescue pastures grazed for 141 days each year for three years produced yearling steers weighing initially 625 lb., daily gains respectively of 1.41, 1.46, 1.32 and 1.18 lb. Grazing days per acre were: 163.8, 165.3, 159.6 and 189. Beef gains per acre of 251.5, 248.6, 217.8 and 249.6 lb. were secured. The yearling steers graded at the end of the grazing period (8–23) from commercial to low good. After a 66 day full feed on concentrate and alfalfa hay the slaughter grades were raised to high good which produced satisfactory cattle for Tennessee markets. The nitrated pasture received 50 lb. of ammonium nitrate for each of 5 applications during season. Practically all the clover dis-

appeared in the nitrated pastures while good to excellent stands of clover were maintained in the unnitrated lots. All pastures received lime, P_2O and K_2O according to recommendations based on soil tests. Steers on the nitrated fescue while building up more days grazing, made slower gains and were appraised $1.52 lower per cwt. than the other lots. They made a relatively poor showing financially compared with other lots because of low gains, low appraisals and additional fertilizer and seeding cost of $13.52 per acre. Net pasture return per acre favored the mixture of orchard-fescue-Ladino with orchard-Ladino and fescue-Ladino being a close second and third.

THE EFFECT OF GROUND CORN ON THE DIGESTIBILITY OF SECOND GROWTH ORCHARDGRASS. W. A. Hardison, C. Y. Ward, J. M. Albert and R. W. Engel, *Virginia Agricultural Experiment Station.*

Recent reports suggest that the lack of benefits from feeding grain to cattle grazing excellent winter forage may be due in part at least to the lowered digestibility of the ration by the addition of the supplement. Other studies with grazing animals as well as with barn fed animals have shown that the addition of grain to a forage ration did not appreciably change the digestibility of the ration. Eight Holstein heifers weighing from 400 to 800 lb. were divided into two comparable groups and used in a single reversal trial to determine the effect of ground corn on the digestibility of orchard grass. The forage was fed fresh twice daily in amounts which were readily consumed by the animals and grain was fed at the rate of 0.5 lb. per 100 lb. body weight. Feces were totally collected over 6-day periods. The average D. M. digestibility (and range) of the total ration for the grain and no grain group was 67.1 (65.0–70.5) and 66.3 (64.2–68.9)%, respectively. The two means are not significantly different from each other.

Physiology Section

E. L. WIGGINS, *Chairman*

THE EFFECTS OF SOME ADRENAL STEROIDS ON SEMEN PRODUCTION IN NORMAL AND ADRENALECTOMIZED RABBITS. Perry T. Cupps, *University of California.*

Injections of 20 mg. daily of cortisone acetate* into normal male rabbits caused loss of libido in four to five weeks and a decrease in the frequency of the formation of the gelatinous portion of the semen. Normal sex drive returned in 4 to 5 weeks following withdrawal of the steroid. The semen collected immediately after libido returned contained a low concentration of spermatozoa. Most of these spermatozoa stained dead with a vital stain and more than 90% of them showed abnormal morphology. The semen became normal about 8 weeks following the withdrawal of the hormone. Histological examination of the testis from normal rabbits treated with 20 mg. of cortisone acetate indicated that such doses stopped spermatogenesis temporarily. In adrenalectomized rabbits high doses of cortisone acetate caused loss of libido within one week.

* Cortone courtesy of Merck & Company.

THE EFFECT OF VARYING PROTEIN INTAKE ON REPRODUCTION, BLOOD COMPOSITION AND WEIGHT CHANGES OF BEEF HEIFERS. E. Bedrak, A. C. Warnick, J. F. Hentges, Jr., T. J. Cunha and J. P. Feaster, *University of Florida.*

Twenty yearling heifers averaging 480 lb. were divided into four groups and fed individually rations which contained the following levels of protein with equivalent amounts of energy, vitamins and minerals: Group I control, recommended N.R.C. level of protein; Group II, 64%; Group III, 31%; and Group IV, 10% of the control ration. Blood samples were taken at 28-day intervals and weights taken every 14 days. One-half of the heifers had been in estrus before the experiment began. All heifers in Groups I and II had at least one estrus during the experiment while 3 in Group III and none in Group IV had one or more estrous periods. The ovaries of anestrous heifers contained no luteal tissue and the largest follicle was 10 mm. as determined by rectal palpation. After 140 days on the above rations, the average hemoglobin values were 10.82, 10.70, 9.31 and 7.58% for Groups I through IV, respectively. The average hematocrit values at this time were 42.19, 41.80, 37.05 and 28.78% for the respective groups. The total serum protein values were 6.68, 6.90, 6.24 and 5.76% for Groups I through IV, respectively. Differences among rations for the above blood constituents were significant at the 1% level. The two lowest levels of protein depressed appetite. The total gains for the 140 day period were 136 and 111 pounds for Groups I and II, respectively, while there was a loss of 4 and 100 lb. in Groups III and IV.

THE EFFECT OF ORAL DIETHYSTILBESTROL FEEDING ON REPRODUCTION IN LOW FERTILITY COWS. W. L. Reynolds, A. C. Warnick, M. Koger and R. W. Kidder, *University of Florida and Everglades Experiment Station.*

The effect of oral feeding of 10 mg. of Diethystilbestrol daily in a concentrate ration on estrus and embryonic survival in low fertility cows was studied. Another study of reproductive performance in heifers and parous cows was made. Thirteen cows were fed stilbestrol while 17 received no stilbestrol. Stilbestrol feeding began 25 days before breeding and continued until slaughter 34 days following breeding. All cows fed stilbestrol came into estrus while 4 control cows did not show estrus ($P=0.10$). Of the cows showing estrus, 54% of the controls and 31% of the stilbestrol cows had normal embryos ($P=0.16$). Approximately equal numbers of cows returned to heat within 34 days in both groups. Two cows had regressing embryos in the stilbestrol group compared to none in the controls. A comparable study at the Everglades Station of 14 low fertility cows showed that 33% of the controls and 25% of the stilbestrol cows had normal embryos. There were two cows with regressing embryos in the stilbestrol group and none in the control animals ($P=0.21$). Combining data from these two studies showed that 47% of the controls and 29% of the stilbestrol fed cows had normal embryos ($P=0.12$). In a study of heifers and parous cows the percentage of normal embryos at 34 days was 90% and 75% respectively, which is a much higher embryonic survival than in low fertility cows.

THE EFFECT OF TWO LEVELS OF ENERGY INTAKE ON GROWTH, VARIOUS ORGAN AND ENDOCRINE WEIGHTS AND CARCASS CHARACTERISTICS OF GILTS ON PASTURE. C. E. Haines, A. C. Warnick and H. D. Wallace, *University of Florida.*

Ninety-eight gilts weighing approximately 115 lb. were divided into full and limited (50% energy of full fed) fed groups on pasture to obtain growth and

feed utilization data up to the time of breeding at the second estrous period. At this time limited fed gilts weighed 169.9 lb. compared to 214.6 lb. for the full fed gilts; the respective average daily gains were 0.40 and 1.00 lb. The average feed efficiency was 8.52 lb. for limited and 6.02 lb. for full fed gilts. Two-thirds of the gilts were slaughtered after breeding and the dressing percentage was 76.4 for limited and 78.7 for full fed gilts. The length of carcass and backfat thickness was 28.7 and 1.23 in. for limited gilts compared to 30.0 and 1.70 in. for full fed gilts. All of the above differences due to ration were statistically significant. The relationship of organ and endocrine gland weight to live weight at time of slaughter was determined. The organ weights expressed as a percentage of the live weight for limited and full fed gilts were: heart, 0.26 vs. 0.25; liver, 1.63 vs. 1.51; lungs, 0.65 vs. 0.56; kidney, 0.34 vs. 0.29; and spleen, 0.14 vs. 0.13. The endocrine weights expressed as a percentage of live weight for limited and full fed gilts were: ovaries, 0.0087 vs. 0.0092; adrenals, 0.0052 vs. 0.0044; thyroid, 0.0082 vs. 0.0078; and pituitary, 0.0026 vs. 0.0023. Differences between groups in organ and gland weights were tested for statistical significance and will be reported.

MAINTAINING PREGNANCY WITH HORMONES IN THE SUCROSE-FED RAT. R. L. Hays and K. A. Kendall, *University of Illinois.*

Earlier investigations showing that progesterone enabled rats on a sucrose distilled water diet to carry litters to term raised the question as to the limiting factor or factors in the maintenance of pregnancy in the untreated sucrose-fed rat. Injections of prolactin and of human chorionic gonadotrophin into the sucrose-fed rat were made to gain information as to whether or not luteal function was involved. Female rats weighing 200–240 gm. and injected with 4–6 I.U. of prolactin daily starting on the day of mating had an average of 14.4 corpora lutea and 7.8 living young, as compared to 13.2 corpora lutea and 2.9 living young in the sucrose-fed rats and 13.8 corpora lutea and 9.8 living young in females on a normal diet. The differences in living young were accounted for by the number of implantation sites which had no fetuses. Females injected with ten I.U. of chorionic gonadotrophin daily either with or without prolactin had no living fetuses. This may have been due to improper timing or to an improper dosage.

FACTORS AFFECTING THE NUTRITIONAL VALUE OF THE BACTERIAL CELL. B. Kaufman, W. O. Nelson, R. M. Forbes and R. E. Brown, *University of Illinois.*

Several factors which may affect the nutritional value of bacterial cells have been investigated. Pure cultures of *E. coli* or *L. arabinosus* furnished bacterial cells which were added as the principle source of nitrogen to rations for albino rats. Control rats were fed similar rations in which casein was the principle nitrogen source. The digestibility of dried *E. coli* cells was equivalent to that of a dried sonic preparation of *E. coli* and was greater ($P<0.05$) than the digestibility of intact viable cells of *E. coli*. The biological value of these preparations did not vary significantly. The biological value and digestibility of dried *E. coli* cells were not influenced by the source of nitrogen (ammonium sulfate vs. tryptone) in the growth medium. The biological value of dried *E. coli* cells supplemented with a mixture of histidine, lysine, methionine, phenylalanine, and tryptophane was greater ($P<0.01$) than that of cells supplemented with glycine, and less ($P<0.01$) than that of casein. The biological value of *E. coli* cells supplemented with amino acids was decreased to that of the glycine control when methionine was omitted from the amino acid mixture. The omission of either histidine, lysine, phenylalanine, or

tryptophane was without effect. The biological value of dried *E. coli* cells was greater ($P<0.01$) than the biological value of dried *L. arabinosus* cells. The digestibility of dried *L. arabinosus* cells was greater ($P<0.01$) than the digestibility of dried *E. coli* cells. In all experiments, bacterial protein was significantly lower in digestibility and biological value than casein ($P<0.01$).

METABOLISM OF TRITIUM-LABELED DIETHYLSTILBESTROL BY STEERS. G. E. Mitchell, A. L. Neumann, and H. H. Draper, *University of Illinois.*

The distribution of radioactivity from orally administered tritium-labeled diethylstilbestrol in the tissues and excreta of two steers has been studied. One bile-fistulated steer received one 10 mg. dose of labeled diethylstilbestrol after which bile, feces, and urine were collected for determination of radioactivity. Another steer was fed a total of 100 mg. of labeled hormone in 20 equal-sized daily doses and slaughtered 24 hours after the last dose. Fecal and urine collections were again studied as were various tissue samples. Radioactivity of plated bile and urine samples was determined directly while tissue and fecal samples were ether and alcohol extracted before counting. Extracted samples were fractionated into conjugated and free phenolic fractions. Ninety percent of the radioactivity in the bile obtained from the intact steer at slaughter time was in the conjugated fraction. Radioactivity in the urine accounted for 18.2 and 21.8% of the administered activity in the two steers. This urine activity appeared in the first 6-hour collection period and continued for 72 hours in the steer receiving only one dose. Seventy-three and 79% of the activity of the urine was in the conjugated fraction. Radioactivity of feces accounted for 28.1 and 29.3% of the administered activity in the two steers of which almost all was in the free fraction. Radioactivity of tissues expressed in parts per billion of diethylstilbestrol equivalent was 0.30 for lean meat, 0.35 for internal fat, 9.12 for liver, 4.15 for kidney, less than 0.17 for heart, and less than 0.008 mcg. per 100 ml. of blood. Combustion techniques are being used in attempts to account for unrecovered activity.

A STUDY OF TIME AND METHOD OF HORMONE ADMINISTRATION FOR BEEF HEIFERS. A. L. Neumann, W. W. Albert, and B. C. Breidenstein, *University of Illinois.*

Heifers were chosen for this test as they were reported to respond less than steers to hormone administration in terms of increased gains and reduced feed requirements. Three lots of 16 heifers each were fed 196 days similar fattening rations containing silage, shelled corn, protein supplement, and hay. The heifers were randomly assigned to one of four treatments in each lot (the within-lot treatments thus being triplicated) as follows: A heifers, no implanted hormone; B heifers, 40 mg. diethylstilbestrol implanted at start of test; C heifers, similar dosages implanted at 98 days; and, D heifers 20 mg. of hormone implanted each 28 days. Imposed upon these treatments was the feeding of 5 mg. of hormone daily in one of the lots. Single implants early or midway in the feeding period did not significantly increase ADG although there was a temporary response in each case. Oral administration of hormone, either alone or in combination with implants, resulted in a significant increase in gains. The combination of oral and implanted hormone resulted in an additive response. Intermittent implantation significantly improved gains over the controls as compared with no response to single implants. Serious physiological disturbances including prolapsed uteri, extremely elevated tailheads, excessive mammary developments, and low loins resulted from the combination of intermittent implantation and oral administration of diethylstilbestrol. Less severe disturbances were noted when these treaments were used alone. On-foot

grades were lowered by hormone administration, and three graders consistently overestimated live grades when compared with carcass grades in the hormone-fed or intermittently implanted heifers.

A STUDY OF THE PLACENTAL TRANSFER OF OXYTETRACYCLINE IN PREGNANT SWINE, DOGS AND RABBITS. C. E. Baker, C. H. Lee,* H. L. Olander,** E. A. White and H. G. Luther, *Chas. Pfizer & Co., Inc.*

It has been observed that sows naturally infected with leptospirosis and treated with oxytetracycline give birth to more viable pigs of greater weight than infected sows not so treated. This could be accounted for by a transmission of oxytetracycline through the placenta and studies were made to explore this further in swine, rabbits, and dogs. Sows in late pregnancy given a single injection of 2 mg. oxytetracycline per pound of body weight were delivered 6 hours later by cesarean section. Concentration of the antibiotic in fetal blood was about the same as in the maternal. Concentration of oxytetracycline in amniotic and allantoic fluids was about 25 times that of blood, and in sow urine about 50 times. The placental transmission and concentration of oxytetracycline by sows fed 500 gm. or 1000 gm. of the antibiotic per ton of feed is being studied and will be reported. Similar studies are being conducted with dogs and rabbits and results will be presented.

ESTROGENIC ACTIVITY OF BLOOD, SALIVA, RUMEN INGESTA AND FECES OF CATTLE RECEIVING STILBESTROL. Rodney Preston, Bruce Taylor and Wise Burroughs, *Iowa State College.*

Studies were undertaken to determine physiological routes followed by stilbestrol when injected subcutaneously into the neck region of rumen-fistulated steers. Estrogenic activity of rumen ingesta, saliva, blood and feces were measured at various time intervals following stilbestrol injection, making use of the mouse-uterine-weight-response technique. In the first trial, the mice receiving rumen ingesta collected 72 hours following stilbestrol injection were 3 times as heavy as those receiving rumen ingesta collected prior to injection. No increase was noted 24 hours after injection. Venous blood showed some stimulation at 24 hours but not at 72 hours following injection. In the second trial, rumen samples were collected 0, 1, 2, 3, 5, 7, and 9 days following stilbestrol injection. Uterine weights were increased on the third and fifth days, declined on the seventh day, and showed a normal value on the ninth day. In a third trial, samples of venous blood and feces were collected 0, 1, 2, 3, 4, 5, 6 and 8 days after stilbestrol injection. Uterine weights of mice receiving the feces reached a maximum at 3 days and declined thereafter. Venous blood showed no activity. Saliva collected on the fourth day of this trial showed estrogenic activity following acidification, refluxing and extraction with ether.

THE EFFECT ON MILK PRODUCTION OF FEEDING STILBESTROL TO DAIRY COWS. C. F. Foreman and A. R. Porter, *Iowa State College.*

In two separate experiments 10 mg. of stilbestrol was fed daily to one member from each of five pairs of lactating dairy cows. Average daily milk production varied from 23 to 45 lb. between pairs, for a three-week period prior to stilbestrol feeding. Persistency of milk production was calculated weekly using the average daily production for this three-week period as a base. In 1955 two pairs of cows

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were placed on the experiment. While the controls were slightly more persistent during the first half of the experimental period, the stilbestrol-fed cows were producing at 76% of base milk compared to 65% for their controls at the end of the 16-week period. In 1956 three pairs of cows were fed stilbestrol in the same manner as those in 1955. Again the stilbestrol-fed cows were less persistent than their controls during the first few weeks of the experiment. However, during the entire experimental period of 20 weeks the average daily milk production for the experimental and control animals was 83 and 84%, respectively, of base production. Estrogen was not detected in the blood and milk from non-pregnant cows fed stilbestrol. Immature mouse and rat uterine weight assays were used. Estrogenic activity was noted in milk of pregnant cows fed stilbestrol.

THE EFFECT OF AGE ON THE DISTRIBUTION OF GLUCOSE IN THE BLOOD COMPONENTS OF LAMBS. R. P. King, P. G. Homeyer and W. H. Hale, *Iowa State College.*

Glucose values for whole blood, plasma, and red blood cells were determined on a group of lambs ranging in age from 0 to 106 days. The data indicated a curvilinear regression relationship between the whole blood, plasma, and red blood cell glucose values and the age of the animal. The greatest decrease in glucose values occurred during the first 21 days of age. The glucose values reached a constant level comparable to the glucose levels of the adult animal after 40 days of age. The data showed a marked disappearance of glucose from the red blood cells with an increase in age. There was a linear decrease in the red blood cell packed volume with age up to 54 days. Due to the variability of the red blood cell packed volumes and the low glucose values associated with them. It is suggested that the plasma of sheep blood would serve as a better estimator of the circulating glucose in the adult animal than that of the whole blood.

OBSERVATIONS ON INDUCED ESTRUS IN OVARIECTOMIZED COWS. R. M. Melampy, L. J. Hanka and P. G. Eness, *Iowa State College.*

Nine cows (1 Milking Shorthorn, 1 Jersey, 4 Holsteins, 2 Ayrshires, and 1 Guernsey) were bilaterally ovariectomized and used as experimental animals. The Guernsey weighed 750 lb. whereas the others ranged between 1000 and 1200 lb. Following the subcutaneous injection of various steroid compounds in oil, the cows were checked at 3 hour-intervals for estrus with bulls. Full estrus was induced in cows weighing 1000–1200 lb. with a single injection 0.3 to 0.4 mg. of estradiol benzoate. The Guernsey responded to 0.2 mg. Estrous behavior was blocked in cows receiving 30 mg. or more of progesterone simultaneously with 0.4 mg. of estrogen. Cows (1000–1200 lb.) were brought into full estrus when injected with a priming dose of estrogen (0.2 mg.) and 1 mg. of progesterone. Estrogen-primed cows receiving 4 mg. of testosterone propionate also accepted a bull. Three cows were given 0.4, 0.8, and 1.6 mg. of estradiol benzoate daily for 3 successive periods of 5 days each. The reaction of the vulva and the secretion of mucus were often independent of the degree of estrus. There was no consistent relationship between vaginal temperature and the degree of induced estrus in the 3 ovariectomized cows.

EFFECT OF SHEARING AND EXPOSURE TO ELEVATED AIR TEMPERATURE ON FERTILITY AND EARLY EMBRYO SURVIVAL IN EWES. R. H. Dutt, E. F. Ellington and W. W. Carlton, *University of Kentucky.*

Ewes were exposed to elevated environmental temperature before breeding in November, and the effects on fertility and normalcy of ova studied. Ten ewes were

kept as the control group. Twenty ewes, ten sheared and ten unsheared, were placed in a heated room with the temperature at 90° F. on the twelfth day of the estrual cycle and kept there until slaughtered three days after breeding. At the subsequent estrual period all ewes were artificially inseminated. Percentages of ova fertilized for the control, the hot-room sheared and the hot-room unsheared ewes were 92.9, 69.2 and 42.9 respectively. Percentages of ova classified as abnormal (shrunken cytoplasm, ruptured vitelline membrane, degenerate cells, or cracked zona pellucida) for the three groups were 7.1, 15.4 and 57.1 respectively. Thirty additional ewes were bred at the same time for a study of embryo survival. Ten of these ewes were kept as controls and twenty ewes, ten sheared and ten unsheared, were placed in the heated room (90° F.) eight days after breeding and kept there for sixteen days. None of the ewes returned to heat and upon observational laparotomy 32–35 days after breeding 100% of the control ewes, 100% of the hot-room sheared and 90% of the hot-room unsheared ewes were pregnant. Rectal temperatures for the ewes in the hot room averaged 104.2° F. for the sheared and 105.0° F. for the unsheared ewes, compared to 102.4° F. for the control ewes. It is concluded that fertility and normalcy of ova in ewes exposed to elevated environmental temperatures are more severely affected than survival of the young embryo. Shearing the ewes before exposure to the elevated temperature modified the detrimental effects.

THE EFFECTS OF CORTISONE ON LACTATION IN RATS. Robert M. Johnson and Joseph Meites, *Michigan State University.*

Twenty-one mature female rats were bred and divided into 3 groups of 7 rats each. The litters were reduced at parturition to 7 young each and the dams injected subcutaneously as follows: (1) controls, saline only; (2) 1 mg. cortisone daily; (3) 0.5 mg. cortisone daily. The litters were weighed daily and the dams weekly. Throughout the experimental period the young received only the milk from the dams, the ration being inaccessible to the young. There was no significant weight loss in the control dams throughout the experimental period, 0–19 days post-parturition, (5 gm.). The average weight gain of their litters for the same period was 178.50±8.65 gm. The dams receiving 1 mg. cortisone daily had a considerable weight loss in the same experimental period (45.50 gm.) but maintained their young at nearly the same rate as the controls (183.83±3.92 gm.). On the other hand the dams receiving 0.5 mg. cortisone daily had a slight weight loss (19.60 gm.) but the weights of their young were greatly increased over those of the controls and the 1 mg. cortisone level (222.40±3.87 gm.). These data support the view that the glucocorticoids play an active role in lactation.

FACTORS INFLUENCING BLOOD LIPID LEVELS AND THEIR RELATIONSHIP TO CARCASS CHARACTERISTICS OF SWINE. R. E. Morrow, A. M. Pearson, E. P. Reineke and J. A. Hoefer, *Michigan State University.*

Pigs held at temperatures in the range of 0° to 5° C. had higher levels of blood lipids than similar pigs held at 14° to 15° C. A diurnal variation in blood lipid levels was noted with low values occurring around 4 p.m. and highest values approximately 12 hours later. Pigs maintained in an air conditioned house in the range of 18° to 24° C. showed less variation in blood lipid levels than similar pigs maintained in an ordinary colony house, indicating temperature fluctuations cause variation in blood fat levels. Carcass characteristics studied with blood lipids were live probe, dressing percent, carcass length, backfat thickness, lean cuts live weight

and carcass weight, primal cuts live weight and carcass weight, specific gravity of right ham, lean loin area at last rib and at the 10th rib and percent of fat trim. At present blood lipid levels have been studied at slaughter for the following: 25 Cnester Whites, 15 Yorkshires, 31 Durocs, 4 Hampshires, 2 Poland Chinas and 8 Chester-Duroc crosses. Although carcass data on the relationship between blood lipids and other measures of leanness and/or fatness are conflicting, results indicate that blood lipids are significantly correlated with the loin lean area. Correlation coefficients for level of blood lipids and area of the Longissimus dorsi muscle at either the 10th or last rib were negative and highly significant for all breeds combined and for most breeds as a group. There was also a tendency for fat trim to be negatively related to blood fat. Although blood fat may be useful as an index to certain carcass traits, temperature and time of day make it difficult to obtain standardized blood samples.

DIGESTIVE TRACT INVESTIGATIONS OF THE BOVINE USING A DUODENAL FISTULA TECHNIQUE. A. Dare McGilliard, C. W. Duncan and C. F. Huffman, *Michigan State University*.

A re-entrant duodenal fistula has been established in a Holstein steer in order to study digestion and passage of nutrients in the alimentary tract. All of the ingesta leaving the abomasum flows from the lower to the upper segment of the duodenum through an exteriorized plastic U-tube which can be conveniently removed for making collections. Three methods of collection were employed in an attempt to establish a technique physiologically suitable for obtaining ingesta over long time intervals. Method I—none of the collected ingesta was re-introduced into the lower digestive tract. Method II—all of the ingesta obtained during each fifteen minute period was re-introduced into the lower tract at the end of the period. Method III—ingesta was continuously re-introduced into the lower tract at approximately the same rate as it was collected. There appeared to be no appreciable difference between collection techniques when the total volume, dry matter, organic matter or ash for six-hour collection periods were compared. If, however, 15 minute plots were made, the data seemed to indicate that continuous reintroduction of ingesta into the lower digestive tract was physiologically more sound than the other methods used.

THE RATES OF DIGESTION OF DIFFERENT PLANT FRACTIONS BY RUMEN MICROORGANISMS *IN VITRO*. R. L. Salsbury and R. W. Luecke, *Michigan State University*.

When the rate of digestion of cellulose in alfalfa meal, as determined by the method of Crampton and Maynard, was compared with that of a wood cellulose (Solka-Floc), it was found that the alfalfa meal showed a more rapid initial rate. Wheat straw was characterized by a fairly slow and uniform rate throughout the incubation period. Extraction of the alfalfa meal with benzene: alcohol caused little change in the initial rate of cellulose digestion but a similar treatment of the wheat straw caused an appreciable increase in the initial rate. Holocellulose preparations from alfalfa meal and wheat straw showed initial rates of cellulose digestion which approximated that of alfalfa meal. The α-cellulose from wheat straw showed an initial rate which was somewhat slower than that shown by holocellulose but faster than that shown by wheat straw or Solka-Floc. The initial rate of digestion of Solka-Floc was increased slightly by the addition of a hot water extract of alfalfa meal and increased appreciably by the addition of alfalfa hemicellulose.

HORMONAL CONTROL OF MAMMARY GROWTH AND LACTATION. J. E. Nellor and E. P. Reineke, *Michigan State University.*

Various levels of hormonal treatment including stilbestrol alone (1.75 mg.), or stilbestrol (1.75, .875 or .07 mg.) in combinaiton with 70 mg. progesterone were injected as a crystalline suspension once weekly for nine weeks into immature and adult anestrous female goats. Each treatment was terminated with two weekly injections of 1.75 mg. stilbestrol. In the last three groups this resulted in ratios of progesterone to stilbestrol of 40:1, 80:1 and 1000:1 respectively. The milk production plateau was reached within 30 days for the 40:1 and 80:1 hormonal ratio; the 1000:1 ratio group did not plateau until 60 days post-treatment. In the stilbestrol group lactation increased very slowly and did not reach a peak until 6 months post-treatment. The most uniform response was obtained with the 80:1 and 40:1 ratios where all animals responded with a production peak average of 1061 and 862 ml. daily, respectively, the range in production being 683–2190 ml. daily. The highest average production was realized in three does in the 1000:1 group (1683 ml.) but only 3 of 5 responded at this ratio. There were no detectible differences in the degree of response shown by kids, yearlings or aged does in any of the treated groups. Retreatment of two kids that failed to respond at the 1000:1 ratio, with 9 weekly injections at the 80:1 ratio resulted in mammary growth and lactation comparable to that in animals treated initially at this level. There is a great latitude in the ratios that can induce mammary development and lactation in goats but it would seem that the 80:1 ratio is more effective in establishing peak production in the shortest time, whereas all treated groups produced the same average amount of milk daily 7 months post-treatment.

EFFECT OF ANTEMORTEM STRESS ON POSTMORTEM BEEF CARCASS CHARACTERISTICS. D. E. Brady and H. B. Hedrick, *University of Missouri.*

From studies conducted with 48 head of cattle it is concluded that dark cutting beef is caused by animals being subjected to prolonged stress prior to slaughter. Associated with stress is an increased secretion of adrenaline which mobilizes blood glucose at the expense of tissue glycogen. Dark cutting beef can be produced experimentally by exciting animals periodically over a 24-hour period with an electric "hot shot". Subcutaneous or intramuscular injections of adrenaline approximately 24 hours prior to slaughter will likewise produce dark cutting carcasses. Injection of 2 mg. of adrenaline per 100 lb. of live weight was the minimal dosage required to produce "shady" carcasses. Three mg. of adrenaline per 100 lb. live weight produced dark cutting carcasses with pH values ranging from 6.0 to 6.25. Increasing the dosage of adrenaline resulted in a higher pH value and a proportional darkening of the color. Discussed are preliminary results of remedial measures to control this condition.

RELATIVE IMPORTANCE OF SWEATING AND DIFFUSION IN EVAPORATIVE COOLING IN CATTLE, RABBITS, AND OTHER SPECIES. Harold D. Johnson, Chu Shan Cheng and Samuel Brody, *University of Missouri.*

A comparative study of the physiological reactions of the rabbit and the dairy cow to rising environmental temperatures (65° to 105° F.), under controlled climatic laboratory conditions, revealed a slow rise in respiratory vaporization—a range of 75 to 160 Cal. per hr. in cattle and 0.84 to 1.4 Cal. per hr. in rabbits. The surface vaporization, which was obtained by partitioning the total by respiratory vaporization, increased in about the same order. However, between 65° and

85° F. cattle surface vaporization increased approximately 75%—from 200 Cal. per hr. to a maximum value of about 350 Cal./Hr.—whereas in rabbits there was only an increase of 28%—from 1.3 to 1.8 Cal. per hr. This sudden rise in surface vaporization between 65° and 85° F. in cows may be analogous to "breaking out in sweat" in man at about 80° to 90° F. This is not apparent in the rabbits which presumably lose all of the surface insensible moisture by a simple diffusion process. A partition of the total evaporative moisture loss into respiratory and surface vaporization reveals that rabbits, cattle, and rats lose approximately 60–80% of this moisture by surface vaporization. Similar values are reported for man, although absolute or total losses differ enormously in species, especially above 80° F. The relative importance of the processes of sweating and diffusion may be generally expressed by comparing the ratios of total evaporative cooling to heat production of sweating and non-sweating animals. Around 100° F., rabbits dissipate only 35% and rats 60% of the heat by evaporative cooling; whereas cattle and man dissipate approximately 100% and 150%, respectively. (Supported by AEC). Mo. Agr. Sta. Journal Series No. 1654. Approved by Director.

EFFECTS OF ADDING HEXESTROL AND RUMEN ORGANISMS TO A CATTLE FATTENING RATION. A. J. Dyer, W. H. Pfander, D. E. Brady and C. W. Turner,* *University of Missouri.*

The addition of Hexestrol (di-hydro Stilbestrol) to a fattening ration for two year old steers had the following effects in two trials, respectively: 26% and 20% increase in rate of gain; 12% and 5% increase in feed consumption; 11% and 5% greater feed efficiency; slightly higher carcass grade because of more marbling; little difference in amount of subcutaneous fat; slightly larger rib eye area determined by tracings and negligible difference in other carcass measurements; little difference in aroma, flavor, and juiciness, but much more tenderness in favor of the Hexestrol-fed cattle as determined by taste panel. Amount of Hexestrol residue in tissue was negligible. Adding rumen organisms (4 mg. per head daily) to one lot in the first trial increased the rate of gain over controls by 6% but made no change in the feed consumed or feed efficiency. Cattle weighed approximately 820 lb. at the beginning and during the trials of 112 and 120 days, respectively, daily gains of Hexestrol-fed cattle (10 mg. per head daily) were 3.2 and 3.4 lb. and for the controls, 2.5 and 2.8 lb.

THE EFFECT OF NITRATE ON REPRODUCTION AND LACTATION. M.E. Muhrer, G. B. Garner, W. H. Pfander and B. L. O'Dell, *University of Missouri.*

Many field observations in Missouri indicate that cattle being fed forages containing sub-lethal levels of nitrate (.5 to 1.5%) have reproduction and lactation abnormalities. Higher levels of nitrate will cause death in ruminants, especially cattle. Either abortions, in apparently disease free cattle, and/or decreased milk production has been observed to occur when the forages consumed contained about 1% KNO_3 equivalent. Three groups of female rats were used to study the effect of nitrate on reproduction. All 12 control rats produced normal litters. Nine out of 12 animals produced litters on a 1% KNO_3 ration. Two out of 8 animals produced litters on a 2% KNO_3 ration. It was observed that four of these animals produced placental tissue but did not produce litters indicating that the fetuses had been absorbed or aborted. A marked drop in milk production in a Jersey cow

* Also: H. D. Nauman, H. Headrick, R. L. Henrickson.

resulted from the addition of 1.25% KNO_3 to her ration. Another animal on .75% KNO_3 showed a similar but less marked drop in milk production. The cow on the higher level of KNO_3 dropped from about 20 to 10 lb. of 5% butterfat milk. The effect of the lower level of nitrate could be partially reversed by the addition of extra energy in the form of molasses to the diet. However, the cow given the 1.25% KNO_3 for 15 days did not completely return to the control level of milk production and finally died 30 days later. Contribution from the Missouri Agricultural Experiment Station. Journal Series No. 1662. Approved by Director.

THE ABSORPTION OF GLUCOSE, LACTIC ACID, POTASSIUM NITRATE POTASSIUM NITRITE FROM THE RUMEN OF MATURE WETHERS. W. H. Pfander, W. C. Ellis, G. B. Garner and M. E. Muhrer, *University of Missouri.*

The experimental techniques previously described (Pfander and Phillipson, J. Physiol. 122:102, 1953) were used to obtain information on the absorption of 5% glucose, 0.067% potassium nitrate, 0.067% potassium nitrite and 0.2% lactic acid from the rumen of mature wethers. Each test substance was added in three liters of warm Krebs-Ringer bicarbonate containing 120 meq. volatile fatty acids per liter. Experiments lasted 2 or 3 hours. Methods used to determine unabsorbed test substances were: glucose, Folin and Wu; nitrate, Garner, *et al.*, nitrite, alpha naphtholamine, (Anal. Chem., 1956) lactic acid, colormetric. In each experiment volatile fatty acids were absorbed at the rate previously reported and small amounts of lactic acid were absorbed. No evidence of glucose, nitrate or nitrite absorption was obtained either by the disappearance from the rumen or appearance in the blood stream. In intact sheep 0.067% KNO_2 given orally resulted in death within two hours. These results suggest that toxic effects observed following the ingestion of forages high in nitrate depend on the conversion of nitrate to nitrite and its passage to the lower g.i. tract: Under most rationing systems the absorption of glucose from the rumen would not seem to be a significant factor in the overall energy metabolism of wethers fed maintenance rations. Contribution from the Missouri Agri. Experiment Station, Journal Series No. 1662. Approved by Director.

A TECHNIQUE FOR *IN VIVO* MEASUREMENT OF THYROID I^{131} IN CATTLE AND ITS APPLICATION DURING EXPERIMENTAL ALTERATION OF THYROID FUNCTION. G. W. Pipes, B. N. Premachandra and C. W. Turner, *University of Missouri.*

In order to study the changes in thyroid activity during various physiological states and to investigate the relationship between thyroid activity and productivity, studies have been made of techniques for evaluation of thyroid function. Equipment has been devised that makes possible quanitative study of changes of thyroidal I^{131} in the bovine, employing a scintillation counting system which permits measurements of highly statistical significance. Three criteria of thyroid function in cattle are purposed. First, the relative rate of thyroid hormone release corrected for reutilization, second, the rate of release of thyroid hormone when goitrogens are employed to prevent reutilization of I^{131} and third the amount of L.-thyroxine required to inhibit the thyroid-pituitary system. Data is presented on the normal uptake and release rate of thyroidal I^{131}. One gram of thiouracil or 6 methyl thiouracil has been found to inhibit reutilization of I^{131} in the mature bovine with larger amounts being required for the calf. Dosage ranging between 0.1 mg. and 0.8 mg. of L-thyroxine have been required to inhibit the thyroid-pituitary system. Mo. Agr. Expt. Sta. Journal Series No. 1651. Approved by Director.

THE EFFECT OF VARIOUS STIMULI ON THE BLOOD LEVELS OF 17-HYDROXYCORTICOSTEROIDS IN CATTLE. Jack Saroff and C. W. Turner, *University of Missouri.*

Stress in dairy cattle leads to reduced milk production and growth. In beef cattle, stress before slaughter produces undesirable changes in the carcass. In order to obtain an objective measure of the degree of stress produced by various stimuli, the blood plasma levels of 17-hydroxycorticosteroid, the blood glucose and eosinophil counts have been determined. The effect of stimulation of the animal with an electrical "hot-shot" type prod, or the injection of adrenaline has been measured. When animals are given an electrical stress or injected with at least 2 mg. of adrenaline per 100 lb. body weight, in almost every case there was an increase in 17-hydroxycorticosteroids from about 4 to about 8 mcg. per 100 ml. of plasma. At the same time, there was a precipitous rise in blood sugar from 50 mg. to about 200 mg. %. The circulating blood eosinophils dropped from 50 to 85%. The effects of other types of stress upon cattle will be measured using the above criteria. Mo. Agr. Exp. Sta. Journal Series No. 1652. Approved by Director.

THE EXCRETION OF ESTROGENS AND PREGNANEDIOL IN THE URINE AND FECES OF COWS IN LATE PREGNANCY. Tawfik El Attar and C. W. Turner, *University of Missouri.*

There are no reports in the literature concerning the determination, simultaneously, of excretion of estrogens in the bovine urine and feces. This study had as its objective the chemical determination of the estrogens and pregnanediol during late pregnancy with the objective of determining the total estrogen excreted, the ratio between the amounts in the urine and the feces, and the ratio of the three estrogens (estradiol, estrone, and estriol) excreted by these pathways. It was found that there was a gradual increase in the total amount of estrogens excreted per 24 hrs. in the urine and feces from 3.58 mg. during the eighth month of gestation to 12.83 mg. just four days before parturition. The major pathway of excretion of estrogens is via the feces with estradiol predominant except near parturition when estriol increased. The average ratio between the total urinary and fecal estrogens was 1:3 respectively. The ratio of the several estrogens estrone, estradiol, and estriol was 1:3.3:2.7 in the urine while this ratio was 1:9.3:6.5 in the feces. No pregnanediol was found in the urine. Mo. Agr. Expt. Sta. Journal Series No. 1653. Approved by Director.

EFFECT OF CHLORTETRACYCLINE (AUREOMYCIN), DIETHYLSTILBESTROL, AND CHLORTETRACYCLINE-DIETHYLSTILBESTROL IN COMBINATION ON FEEDER CALVES FED A FINISHING RATION. S. C. Stothers and E. W. Stringam, *University of Manitoba.*

Four lots of seven steers, each averaging approximately 435 pounds initially, were fed a basal ration of barley, oats, linseed oil meal, hay and minerals for a 195 day period plus the following treatments: Lot 1, Control; Lot 2, Control + 10 mg. of chlortetracycline per live hundredweight daily; Lot 3, Control + 10 mg. diethylstilbestrol per steer daily; Lot 4, Control + chlortetracycline and diethylstilbestrol at the same levels as in Lots 2 and 3. One death in Lot 4 and other causes involving two steers in Lot 1, and one in Lot 3, necessitated the removal of four steers and their data in calculating the final results. Average daily gains (pounds) from Lots 1 to 4 respectively were as follows: 1.79, 1.78, 1.88, and 2.08. Similarly, pounds of feed per lb. of gain were as follows: 9.01, 8.88, 8.36, and 8.02 there were no appreciable differences in carcass grades.

THE EFFECTS OF A WATER-DISPERSIBLE OIL AND OF PENICILLIN ON CHARACTERISTICS OF RUMEN INGESTA AND ON BLOAT. R. H. Johnson, L. R. Brown and N. L. Jacobson, *Iowa State College.*

Twenty-five Holstein steers (average initial weight 620 lb.) on alfalfa pasture were divided into two groups. Alternately during 2-week periods each group served as control or received a water-dispersible oil (supplied by Midwest Dried Milk Co., Dundee, Ill.) at a level of 1% in the drinking water. Although bloating was not intense, incidence and severity were reduced by the treatment. Weight gains and water consumption were slightly greater for treated animals. The average surface tension value of rumen ingesta from controls was 63.7 and from treated animals was 57.2 dynes per cm. Foam volume and stability, pH, specific gravity and viscosity were altered only slightly. An additional 15 dairy animals (average initial weight 520 lb.) receiving fresh chopped alfalfa ad libitum in dry lot were employed to study the effects of administration of a penicillin feeding supplement (Merck). The animals were divided into two groups which alternately served as controls or received penicillin by capsule at the rate of 75 mg. per animal per day. The penicillin was administered for a period of 10 days followed by a control period of at least 5 weeks. The average surface tension values of rumen ingesta from controls was 56.7 and from animals receiving penicillin was 56.0. Foam volume was slightly greater and foam stability slightly lower in the treated animals. Weight gains were not appreciably altered by penicillin feeding. Incidence of bloat, which was relatively low even in untreated animals, was somewhat reduced by penicillin but response varied greatly among animals.

LEVELS OF ALFALFA FEEDING IN SWINE REPRODUCTION TRIALS. A. E. Flower, O. O. Thomas and S. W. Tilton, *Montana State College.*

Five lots containing nine sows and gilts per lot were fed reproduction rations with alfalfa percentage as the chief variable during the breeding and gestation periods. Lots I and III received a mixed, self-fed diet of 50% alfalfa added to the concentrate which also included minerals. Lots II and IV received alfalfa free choice from racks with no additional nutrients other than minerals fed free choice from dispensers. Some pasture was available during early winter and early spring, however, Lot V received 20% alfalfa in what was considered to be a well-balanced control ration. No significant differences among lots were noted in any reproductive or lactation characteristics studied, although differences among means and high error terms in analyses indicate that differences may exist which are difficult to measure statistically. Highly significant differences were observed between treatments in weight changes of females during gestation. Weight changes during lactation generally followed a pattern of appreciable gain for those sows which had been on the straight alfalfa diet during gestation. Those sows which had been on 50 and 20% alfalfa diets during gestation lost weight during lactation. Quality of alfalfa used in these trials was only fair.

INFLUENCE OF SPERM CONCENTRATION, INITIAL FRUCTOSE LEVELS, AND ADDED FRUCTOSE ON FRUCTOLYTIC ACTIVITY OF BOVINE SPERMATOZOA. Matthew Freund and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

Fructose utilization by 70 semen samples from 12 dairy bulls was determined during 20, 40, and 60 minutes of incubation at 36° C. in a 2.9% sodium citrate solution. Mean semen values were 1.220 billion sperm per ml., 4.96 mg. per ml. of fructose initially and fructose utilizations for 20, 40, and 60 minutes of incubation

were 0.88, 1.57, and 2.12 mg. per ml. of semen. On a "within bull" basis both sperm concentration and initial fructose level significantly influenced fructose utilization in one hour with a multiple correlation of 0.63. In a 30-sample split ejaculate study, mean fructose utilization per ml. of semen was increased from 2.00 to 3.23 mg. in one hour by raising the initial fructose level from 3.94 to 7.19 mg. per ml. by addition of fructose. To adjust fructose utilization for the effects of sperm concentration and initial fructose level using regression technique, appropriate partial regression coefficients were calculated from the 70-sample, one-hour data on a "within bull" basis and integrated to give the adjustment formula,

adjusted $Y_3 = Y_3 - 0.679(X_1 - 1.0) - 0.354(X_2 - 5.0)$

in which Y_3=mg. of fructose utilized in one hour by one ml. of semen, adjusted $Y_3 = Y_3$ adjusted to a basis of one billion sperm and an initial fructose level of 5.0 mg. per ml., X_1=billions of sperm per ml. of semen, and X_2=initial fructose level of the semen in mg. per ml. The mean adjusted fructose utilization for the 70 semen samples was 1.99 mg. per hour.

PENICILLIN AS A PREVENTIVE OF BLOAT IN THE FIELD WITH CONCURRENT LABORATORY STUDIES ON RUMEN CONTENTS. W. E. Thomas, *North Carolina State College.*

Starting in mid-April many fields of white or Ladino clover in the coastal area of North Carolina could not be grazed without bloat losses. These pastures were only 3 to 6 inches tall and were essentially pure stands. Hay feeding was not effective in preventing bloat. A total of 36 beef cows in two herds were divided at random and 18 dosed orally with feed-grade penicillin. When 100 mg. of procaine penicillin was administered no bloating was observed after 12 or up to 96 hours. Twenty-four cases of bloat were observed among the untreated group during a 48 hour comparison period. Two rumen fistulated dairy cows were hauled to one farm and six to another and turned on the bloating pastures. Studies on the rumen contents of these animals were made in the field and in the laboratory. The specific gravity of the rumen contents of a fistulated cow was increased from 0.46 before treatment to 0.93 in 12 hours by 100 mg. of penicillin per animal. Instead of frothing, penicillin treated animals developed an air pocket above the ingesta. Total gas production and ingesta volume increases were not consistent before and after penicillin treatments. Digestibility values, using the ratio technique, did not show differences when 0, 30 or 300 mg. of penicillin were administered two days previously. Microbiological studies of rumen and fecal samples were inconsistent.

THE EFFECT OF SYNTHALIN A ON BLOOD GLUCOSE LEVELS AND LIVER FUNCTION IN DAIRY BULL CALVES. J. P. Mixner and W. G. Robertson, *New Jersey Agricultural Experiment Station.*

It has been suggested that synthalin A exerts a hypoglycemic action through a selective necrotic action on alpha cells of the Isles of Langerhan and the subsequent lowering of a hyperglycemic factor (HGF or gulcagon). This hypoglycemic action might also be mediated by hepatic dysfunction and a lowering of gluconeogenic activity, or by a combination of these and other effects. Synthalin A was injected intramuscularly into for dairy bull calves at the rate of 3.3 mg. per kg. of body weight. About 18 hours later a bromsulphalein liver function test was performed in three animals, one having died. Results of liver function tests are expressed as per cent of normal. Blood glucose, blood hematocrit, and plasma and blood volumes per kg. of body weight were determined from blood drawn at the time the liver function tests were performed. Four normal calves served as

controls. Following is a comparison of the various mean measurements made in the control and synthalin A injected calves, respectively: body weight—39.9 and 48.5 kg.; blood glucose—108.7 and 8.1 mg. %; liver function—100 and 34.5%; hematocrit—41.5 and 49.7%; plasma volume per kg. of body weight—81.6 and 50.3 ml.; blood volume per kg. of body weight—136.1 and 93.8 ml. These results suggested that the effects of synthalin A on blood glucose could be entirely a function of the marked hepatic dysfunction demonstrated.

ANIMAL, DAILY, DIURNAL AND METHOD SOURCES OF VARIATION IN PLASMA PROTEIN-BOUND IODINE LEVELS IN DAIRY CATTLE.[1] H. D. Lennon, Jr. and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

Four groups of dairy animals consisting of three heifer calves (3–6 months old); three open heifers (15–18 months old); three pregnant, non-lactating cows; and three lactating, non-pregnant cows were used in a study to determine the effects of animal, daily, diurnal and method sources of variation on plasma protein-bound iodine (PBI) levels. The study was conducted in three runs, each run consisting of four animals, one animal being from each of the above groups. Blood samples were collected from each animal at 8 a.m., 4 p.m., and 12 p.m. on each of four alternate days for one week. Three separate fusions were performed on each plasma sample and one photometric determination was performed on each fusion tube using the method of Brown *et al.* (J. Clin. Endoc. Metabolism, 13:440. 1953). Group, run and run × group effects on PBI (collectively animal effects) contributed 23.7%, 9.4%, and 54.7% respectively to the total variance. The effect of daily variation (within run) on PBI was highly significant statistically yet contributed less than 1% to the total variance. Diurnal variation as measured by hour effects was not statistically significant and contributed nothing to the total variance. Sources of variance were combined under three main headings, animal, sampling effects and assay errors which contributed respectively 87.8%, 9.73%, and 2.50% to the total variance. The sampling effects were composed mainly of the interaction of hour with day and their interactions with group and run.

SEMEN PRODUCTION AND FERTILITY OF YOUNG BULLS RAISED ON THREE DIFFERENT LEVELS OF FEED INTAKE. R. W. Bratton, S. D. Musgrave, H. O. Dunn, R. H. Foote and C. R. Henderson, *Cornell University.*

Thirty Holstein bulls are being raised from the first through the 80th week of age on either a low, medium or high level of feed intake planned to furnish 60 to 75, 100, and 140 to 160% of the upper range of Morrison's recommended allowances of TDN for growing dairy heifers. The low level provides small amounts of whole milk, starter, grower, and poor quality mixed hay; the medium level more milk, starter, grower, and mixed hay of good quality; the high level still more milk, starter, and grower in essentially ad libitum amounts with high quality mixed hay or second cutting alfalfa limited to encourage a greater consumption of concentrates, and vitamin A and D and mineral supplements. None of the groups receive pasture. The average ages, weights, and heights at withers of five trios of bulls at the onset of semen production were, respectively, 57 wk., 562 lb., 46.0 in., for the low level; 49 wk., 634 lb., and 45.3 in., for the medium level; and 43 wk., 727 lb., and 47.6 in., for the high level. Semen was collected at 14-day intervals and, up to 80 weeks, the number of ejaculates obtained, the

[1] Supported in part by Research and Marketing Funds (sec. 10b) of the Agricultural Research Service, Dairy Husbandry Research Branch, U. S. Department of Agriculture.

motile sperm per ejaculate, and the 60- to 90-day nonreturns to 1st services were, respectively, 12, 2.3×10^9, and 74.1 for the low level, 14, 3.8×10^9, and 72.9 for the medium level and, 19, 3.7×10^9, and 74.2 for the high level.

ASCARICIDAL ACTIVITY OF PIPERAZINE ADMINISTERED IN THE FEED TO SWINE. James E. Guthrie and James E. Briggs, *Hess and Clark Inc.*

A series of experiments were conducted to evaluate the anthelmintic activity of two piperazine compounds against *Ascaris lumbricoides*. The trials were conducted according to Hall's critical test which is the accepted method for evaluating anthelmintic drugs. Piperazine sulfate was given in a balanced ration for 24 hours with no prior fast in 4 trials. At a concentration of 0.4% in the feed, 89% of 156 worms were removed from 11 hogs weighing 100 lb. with a mean dosage of 44.6 mg. piperazine per lb. of body weight. A 0.42% level removed 93% of 103 worms with an average dosage of 41.4 mg. per lb. being consumed by 7 shotes weighing 104 lb. With 0.44% in the feed 90% of 132 worms were removed from 7 65 lb. pigs with a mean dosage of 57.5 mg. piperazine per lb. Seventeen 58 lb. pigs given 0.45% of the drug eliminated 85% of 283 worms after a mean dosage of 73 mg. piperazine per lb. With a 16-hour fast prior to treatment, four 99 lb. pigs passed 98% of 104 worms with a dosage of 58.6 mg. per lb. of piperazine. Piperazine phosphate given for 24 hours at 0.25% and 0.33% of the ration with no prior fast to eleven 59 lb. pigs and ten 49 lb. pigs removed 49% of 157 and 60% of 190 worms with a mean piperazine dosage of 33.2 and 41.6 mg. per lb.

BIOCHEMISTRY OF BRUISED TISSUE WITH REFERNECE TO DETERMINING THE AGE OF A BRUISE. M. K. Hamdy, L. E. Kunkle and F. E. Deatherage, *Ohio Agricultural Experiment Station and the Ohio State University.*

Some morphological and biochemical changes in bruised tissues were investigated. The "easily split iron" fraction resulting from the degradation of hemoglobin increased in concentration after infliction of the bruise and then decreased with healing to reach the normal level. The non-protein nitrogen was found to decrease followed by a considerable increase probably due to enhanced tissue catabolism and globin degradation. Extravascular hemoglobin was found to increase in concentration and to decline to normal values upon complete healing. This free hemoglobin was degraded to hematin which subsequently lost its iron and was then oxidized to form the bile pigment bilirubin. The latter increased in concentration, then decreased and finally disappeared from bruised tissue upon complete healing. Spectrophotometric studies of normal and bruised tissues were made at various stages of healing. A color test for bilirubin was devised for approximating the age of a bruise. Conductivity measurements indicate that the resistance offered by a bruised tissue is quantitatively affected by the age of the bruised tissue. Using both the color test and the conductivity measurements, it is possible to determine the approximate age of an unknown bruise. A number of factors was found to affect the extent of bruising and the rate of healing.

RELATIONSHIP BETWEEN BODY WATER, AS DETERMINED BY ANTIPYRINE, AND CARCASS DATA OF CHOICE STEERS AND HEIFERS. Earle W. Klosterman, R. R. Johnson, V. R. Cahill and G. M. Tallis, *Ohio Agricultural Experiment Station.*

Percentage body water was determined on 12 steers and 12 heifers by use of the antipyrine technique. These animals were of similar age—approximately 15

months—and breeding and had been full fed a fattening ration in dry lot for over 200 days. Of the 24 animals in which antipyrine measurements were made 18 appeared to give reasonable estimates of body water. The mean percentage body water of these 18 animals was 60.5±2.1. All animals were slaughtered in the Meats Laboratory where detailed slaughter data were obtained. The carcass grades of the 18 animals were: 1 high good, 7 low choice, 7 average choice and 3 high choice. One half of each carcass was separated into edible portion, bone and fat trim. The edible portion of the carcass is designated as edible meat with no more than three-eighths inch layer of fat on any surface. The average percentages of edible portion and fat trim of the carcasses were 67.1±0.3 and 18.2±0.4, respectively. Within the relatively narrow range of degree of fatness of the animals studied there were no significant correlations between percentage body water of the live animal, as determined by antipyrine, and percentage edible portion or fat trim of the carcass.

THE EFFECT OF INCLUDING ALFALFA, AN EXTRACT OF ALFALFA MEAL OR LOW LEVELS OF STILBESTROL IN DRY LOT BREEDING-GESTATION RATIONS FOR SWINE. H. S. Teague and Edgar P. Young, *Ohio Agricultural Experiment Station.*

In previous studies, the inclusion of 18% sun-cured alfalfa in a dry lot breeding-gestation ration for swine appeared to increase ovulation rate and the number of live pigs farrowed. The reproductive organs of 109 Duroc gilts were examined 25 to 27 days after breeding in four experiments to determine whether the beneficial influence of alfalfa noted previously would result from the feeding of an acetone-hexane extract of dehydrated alfalfa or whether the estrogenic activity reportedly present in alfalfa was influencing reproductive performance. In the first trial, the average numbers of corpora lutea and live embryos possessed by gilts fed the 18% alfalfa, legume-free ration or legume-free ration plus extract were: 14.17 and 12.67; 12.86 and 9.71; 14.60 and 12.20, respectively. In a second trial, however, neither the addition of the extract nor the non-saponifiable fraction of the extract appeared to influence ovulation rate or the number of embryos. In a fall study and another the following spring, the addition of 0.29 or 0.58 mcg. of stilbestrol per pound of legume-free ration appeared to lower ovulation rate and decrease embryonic survival. The rations fed and average numbers of corpora lutea and live embryos were: (fall) 18% alfalfa, 14.12 and 11.00; 18% alfalfa plus 0.29 mcg. stilbestrol, 14.38 and 11.00; legume-free, 14.62 and 10.38; legume-free plus 0.29 mcg. stilbestrol, 12.57 and 7.29; legume-free plus 0.58 mcg. stilbestrol, 13.62 and 7.62; (spring) legume-free, 18.12 and 13.50; legume-free plus 0.29 mcg. stilbestrol, 14.43 and 12.14; and legume-free plus 0.58 mcg. stilbestrol, 14.10 and 10.88.

A STUDY OF THE MODE OF ACTION OF STILBESTROL. E. W. Hartsook and N. D. Magruder, *Pennsylvania State University.*

Ninety-four male albino rats ranging from weaning to mature size were fed by either the paired or ad libitum technic either semi-synthetic 12.5% caesein diets or Rockland Rat diet to which had been added 0, 0.15, 0.3, 0.6, or 2.4 mcg. of diethylstilbestrol (DES) per gram of diet. During the course of the four experiments the effects of dietary DES were evaluated by use of the following criteria: body weight gain; grams of feed per gram of gain; body length; basal metabolic rate (BMR); and milligrams of pituitary, thyroid, and adrenals and grams of testes per 100 gm. of body weight. Decreased body weight gain, increased feed requirement per gram of gain, decreased body length, increased BMR, hyptertrophy of

the pituitary, thyroid, and adrenals, and atrophy of the testes resulted when DES was included in the diets. These changes were statistically significant when the control diet was the basis of comparison.

EFFECTS OF SUBCUTANEOUS DIETHYLSTILBESTROL IMPLANTATION ON LACTATION AND REPRODUCTION IN DAIRY COWS AND HEIFERS. E. R. Becker and H. H. Voelker, *South Dakota State College.*

Sixteen dairy cows and 8 heifer calves averaging 6.5 months of age were used to determine the effects of subcutaneous implantation of diethylstilbestrol pellets. The cows were implanted with levels monthly at 0, 15 mg., 30 mg., and 240 mg. Half of the heifers were implanted with 15 mg. monthly; the others served as controls. The animals were observed daily for evidence of estrus-like symptoms. Periodic veterinary examinations were made on reproductive organs. The milk produced was bioassayed for estrogenic activity by immature mouse uterine response technique. Four replications of 10 mice (10–12 gm.) were used at each level of implantation. Analysis of variance of results to date indicate that homogenized cream of some of the implanted cows may contain estrogenic activity, based on comparisons of known standards of added stilbestrol to mouse diets and to milk from non-pregnant, control cows. Milk production data to date indicate no influence in quantity of production of cows by any levels of implantation. Butterfat percent was characteristically variable in implanted cows. Stilbestrol-implanted heifers less than one year old, stimulated initially by the nursing of younger calves, milked up to 3 lb. daily. Their milk was normal in fat and solids-not-fat content. Stilbestrol implants did not terminate pregnancy in cows. However, implants did induce estrus-like symptoms in non-pregnant cows and heifers. Cervical dilations were noted in some implanted females. Other symptoms in heifers including udder development and depression of sacrosciatic ligaments similar to prepartum are available for showing on 2 by 2 inch slides.

THE EFFECT OF MASSIVE ORAL DOSES OF VITAMIN D ON THE EXCRETION OF PLASMA RADIOPHOSPHORUS. H. R. Conrad, Sam L. Hansard, J. W. Hibbs and H. Patrick, *Tennessee and Ohio Agricultural Experiment Stations.*

Four Hereford steers and two Jersey cows were used in a study of the physiological effects on phosphorus behavior of massive oral quantities of vitamin D (30 million USP units for five days) known to be sufficient to prevent milk fever in cows. A series of fourteen day concurrent phosphorus and radiophosphorus balance and blood studies showed that: (1) Total phosphorus excretion was increased during and immediately following vitamin D feeding. (2) Radiophosphorus excretion in urine was increased slightly during vitamin D feeding and markedly during 1–5 days after vitamin D. (3) Net absorption or true digestibility of phosphorus was increased slightly during vitamin D feeding and markedly during the post feeding period. (4) Total endogenous phosphorus was decreased during vitamin D feeding, but increased toward the pre-feeding level following vitamin D administration. (5) Total blood calcium increased during vitamin D feeding, but declined when feeding was terminated. The increases was accredited principally to the increases in the unbound plasma calcium fraction. Consideration has been given to the possible mechanisms involved. The observed increase in renal excretion and intestinal absorption of phosphorus immediately following the termination of vitamin D feeding appeared to be independent of the changes in the physiological behavior of calcium and may have been associated with increased parathormone secretion.

RED CELL LIFE SPAN OF FARM ANIMALS. Sam L. Hansard and Everett Kincaid, *University of Tennessee.*

Chromium^{51} labeled homologous erythrocytes have been employed in 50 trials with 40 young and mature cattle, sheep, swine and burros to measure the apparent survival time of red cells in farm animals. Whole blood was incubated with isotonic chromium^{51} labeled sodium chromate solution and labeled red cells re-injected quantitatively into the host animal. Radioactivity was measured in periodic blood samples until all detectable radioactivity had disappeared from the circulation and the results expressed as a percent of the chromium^{51} remaining. Mathematical treatment of these data gave values indicating that: 1) Red cell uptake and rate of *in vivo* loss of chromium^{51} from circulating blood was remarkably constant for animals of the same species. 2) Rate of loss during the first 14 days after dosing was 5, 5, 4 and 3% per day for cattle, sheep, burro and swine, respectively, as compared to 2.1, 1.9, 1.7 and 1.4% per day for these species on basis of average rate of loss throughout the period of study. 3) Total percent red cell chromium^{51} retention was greater for swine than for the burro, cattle or sheep, and young of all species retained less. Forty-five days after dosing these values were 5, 12, 15 and 35% remaining in blood of cattle, sheep, burros and swine respectively. 4) Average survival time for red blood cells were calculated for mature swine to be 71±10 days, with that for the burro, cattle and sheep to be 70 to 80% of this value. 6) Consideration will be given to possible influence of observed initial rapid blood chromium disappearance processes upon estimation of red cell life span.

EFFECTS OF WHOLE BODY RADIATION ON SEMEN CHARACTERISTICS IN BULLS. R. L. Murphree and N. R. Parish, *University of Tennessee.*

Limited studies of the effects of ionizing radiation on the fertility of the exposed individuals have been conducted with laboratory animals. A study to evaluate the effects of whole body radiation on fertility in cattle is in progress. This is a report on the effects of radiation upon the semen characteristics in exposed bulls. Groups of sexually mature beef bulls were exposed to the following levels of gamma radiation from a cobalt-60 source: 0, 100, 200, 300 or 400 r. Semen was collected from 35 bulls at weekly intervals and the numbers of sperm, sperm motility, percent live sperm and percent abnormal sperm recorded for each ejaculate. Blood samples were drawn at intervals for hematological analyses. The first observed semen change was an increase in percent abnormal sperm the 6th week, post-exposure. While all bulls were affected, the most severe damage was seen in the 400 r group (11% pre-exposure to 61% abnormal sperm the 13th week, post exposure). A decrease in sperm numbers was evident the 8th week, post-exposure. Sperm numbers were low through the 15th week after which there was a gradual recovery. Sperm motility and percent live sperm were not changed nearly so markedly as were the numbers and percent abnormal sperm. While none of the radiated bulls reached the control level, all were producing good quality semen by the 24th week, post-exposure.

BODY WATER ESTIMATIONS WITH IDENTICAL TWIN DAIRY CATTLE USING ANTIPYRINE. E. W. Swanson and M. W. Neathery, *University of Tennessee.*

Thirteen pairs of identical twin dairy heifers and cows, which were being used in comparisons of growth rate effects, dry period feeding studies, thyroxine feeding, and also in uniform treatments were subjected to repeated estimations

of body water to evaluate this method of detecting differences in body composition. Estimations made after fasting for 16 hr. and withholding water for 12 hr. were less variable within pairs than estimations made without fasting; but the average percentage of body water of 14 animals was the same, 60%, after fasting as without fasting. Seven twins fed at a high plane of nutrition averaged 60% body water compared to 65% for their normal identical mates. This difference was statistically significant. Differences between fattened and normal growing heifers were not significant. In normal animals varying in age from 11 to 58 mo. the correlation between body water and age, r=.01, was not significant. Differences due to thyroxine feeding were hard to interpret because of some abnormal metabolism rates in both the treated and control twins. Metabolism rates that were either high, low or variable frequently resulted in unreasonably body water estimation.

THE EFFECTS OF TWO LEVELS OF ENERGY AND SEASONS ON REPROUCTIVE PHENOMENA OF GILTS. J. W. Gossett and A. M. Sorensen, Jr., *Texas Agricultural Experiment Station.*

A group of 32 spring farrowed gilts averaging 40 lb. and a group of 36 fall farrowed gilts averaging 45 lb. in weight were placed on feed in August and January, respectively. These two groups were equally divided according to weight and litter and fed rations containing 50 or 75 therms of productive energy per 100 lb. of feed. All gilts were checked daily with a vasectomized boar after reaching 120 days of age for signs of estrus. The gilts were bred at second estrus and slaughtered 40 days later to obtain ovulation and embryo counts. Fall farrowed gilts reached puberty at an average age of 207 days, while spring farrowed gilts attained puberty at an average age of 216 days, which was significantly different. A significantly greater number of ovulations was observed in the spring gilts as compared to the fall gilts, 13 and 11 respectively. An average of 9 embryos was counted in the spring gilts, and 7 in fall gilts. This difference was highly significant. Gilts in the spring farrowed group consuming the low energy ration reached puberty 21 days earlier than gilts on the high energy ration. Contrary to other reports, the gilts receiving the low energy ration ovulated comparable to the gilts on the high energy ration. There was an average of 8.6 embryos in the spring farrowed gilts and 7.3 in the fall farrowed gilts, which was highly significant.

A COMPARISON OF SLAUGHTER AGES FOR DETERMINING EMBRYONIC MORTALITY IN SWINE. A. M. Sorensen, Jr. and J. W. Gossett. *Texas Agricultural Experiment Station.*

A group of 90 gilts was studied to determine the optimum age at slaughter for obse g embryonic mortality. Thirty-eight of the gilts were slaughtered at 25 days er breeding and mortality was determined by counting the number of copora lutea and the number of live pigs present. Heart and appearance of the embryonic membranes were used as criteria for determining if the embryos were alive. Difficulties in determining mortality at this age are mainly the procurement of the gravid uterus soon enough after slaughter to see the heart beat and the various gradations of development or deterioration of the membranes. The remaining 52 gilts were slaughtered at 40 days of age. This age was chosen because the level of progesterone seems to begin rising at this time. There is very little doubt as to whether the embryo is alive or dead at this stage. Numerous pigs were observed in the resorptive state that would have been counted as live embryos at 25 days. The percent live embryos in the 25 day group was 74 as compared to 67 in the 40 day group. This 7% decrease in live embryos occurred over a period

of only 15 days and from a hormonal standpoint this may be a very critical period. From an economical viewpoint it is much better to carry the gilts 15 more days than it is to increase the number of gilts slaughtered at 25 days to get data as reliable as that from those slaughtered at 40 days.

OVARIAN HORMONES FOR SUCKLING LAMBS FATTENED ON PASTURE. Bryan Baker, Jr., R. C. Carter, J. A. Gaines and J. S. Copenhaver, *Virginia Polytechnic Institute.*

Nineteen pairs of twin lambs were used in this study, thirteen pairs of the same sex, and six pairs of opposite sex. They were born of grade western ewes, and sired by four rams, one Southdown, one Dorset, and two Hampshire. One member of each pair was randomly chosen to receive the hormone treatment, automatically placing the other member in the control group. The hormone pellet, containing 10 mg. estradiol + 250 mg. progesterone, was implanted subcutaneously in the ear when the lamb reached 65 lb. All lambs and their dams were grazed as one flock on bluegrass pasture. Values were obtained for daily gain, yield, and carcass grade. A conventional least squares analysis of these values was accomplished to estimate differences due to breed of sire and treatment, and test the hypotheses that sire breed 1 = sire breed 2 = sire breed 3 and treated lambs = controls. Average daily gains were .602 for the treated lambs and .481 for the controls; this difference was highly significant. Average yield of the treated lambs was 48.22%, and of the controls was 49.37%; this difference was also highly significant. The average carcass grade for all lambs was high good, and the difference between the means of treated lambs and controls was not significant. The differences in yield and carcass grade due to effects of breed of sire were highly siginficant, but there appeared to be no difference in daily gain that was attributable to differences in breed of sire. There were no death losses encountered and no visible evidence of prolapse of rectum or vagina of any of the lambs in this experiment.

FACTORS GOVERNING CELLULOSE DIGESTION IN VIVO. W. E. C. Moore and K. W. King, *Virginia Agricultural Experiment Station.*

Patapar papers of known weight were placed in plastic screen pouches and introduced into the rumens of three steers through permanent fistulas. Samples were removed in duplicate over 20-hour trial periods. Percent digestion was determined gravimetrically and compared with in vitro results from samples incubated with rumen ingesta from the same animals over the same intervals. Results demonstrated greater activity in vivo than in vitro. The measured activity was quantitatively stratified in the rumen and generally fell following feeding. The daily pattern of cellulolytic activity appeared to vary more between days within animals than between animals within days. Separate determinations with competitive substrate, excess end products, controlled water consumption, high grain feeding, readily available carbohydrate, pH, protein, and amount of aeration of rumen ingesta indicated that these factors interact in the control of cellulolytic activity in vivo.

THE USE OF DIETHYLSTILBESTROL WITH ALFALFA SOILAGE FOR FATTENING YEARLING STEERS. W. W. Heinemann and C. R. Kyd, *Washington State College.*

Oral administration of stilbestrol together with half a grain ration the last two-thirds of the soiling season was fed to 60 yearling steers fed alfalfa soilage

during a 163-day feeding period. A similar number of steers, also fed in three lots, served as controls. Cattle fed stilbestrol received 10 mg. per day after 28 days on alfalfa soilage and wheat straw *ad libitum*. Significantly higher average daily gains (2.10 as compared with 1.69 lb. for the controls) were made by the cattle fed stilbestrol but the added cost of the hormone resulted in approximately equal feed costs per pound of gain. About 16% less soilage, 21% less straw and 6% less grain (barley-beet pulp) was consumed per pound of gain by the cattle fed stilbestrol. Soilage feeding was discontinued September 13, after which time a full feed of the pelleted barley-beat pulp was fed for 30 days. The cattle were then marketed. No prominent undesirable carcass characteristics were noted in the stilbestrol-fed cattle at the time of slaughter but their average selling price was 59 cents less per 100 lb. liveweight. The 30-day period without alfalfa soilage resulted in satisfactory removal of yellow fat color. There was no difference in total length of feeding period required for the cattle from either treatment to reach the U. S. Choice grade.

MAINTENANCE OF EARLY PREGNANCY IN OVARIECTOMIZED EWES. W. D. Foote, L. D. Gooch and L. E. Casida, *University of Wisconsin.*

The maintenance of early pregnancy was studied in 52 ewes. Eight intact ewes receiving no treatment were used as controls. The remaining 44 ewes were randomly assigned to 5 hormonal treatments. All ewes were bred approximately 12 hours after the beginning of heat and those assigned to treatment were ovariectomized 84 hours after breeding. The experiment was carried out in three successive trials A, B, and C. All ewes of trial A were injected daily with 1 mg. of progesterone and .01 mg. of estradiol per 5 lb. body weight. Two of five ewes had embryos (possibly abnormal when slaughtered 11 to 18 days after breeding. All of the ewes of trials B and C were slaughtered 25 days after the beginning of heat. The treatments and results of trial B were as follows. Seven ewes receiving 1 mg. of progesterone plus .01 mg. of estradiol daily per 5 lb. body weight and seven receiving twice this dosage all failed to maintain pregnancy. Two of seven ewes receiving 1 mg. of progesterone alone per 5 lb. body weight daily and two of seven given twice this dosage produced embryos. Nine embryos were recovered from six of eight control animals. The ewes of trial C received 1 mg. of progesterone and .25 mcg. of estrone daily per 5 lb. body weight. Six of eleven ewes maintained pregnancy. The average embryo weight for trial C was 174.3 mg. The control embryos averaged 125.9 mg.

THE EFFECT OF GONADOL HORMONES ON THE GONADOTROPHIC POTENCY OF THE PITUITARY AND ON SIMULTANEOUS OVARIAN CHANGES IN THE GILT. W. C. Foote, D. P. Waldorf, H. L. Self and L. S. Casida, *University of Wisconsin.*

Forty-nine gilts (average live wt. 232 lb.) of mixed breeding were divided into five experimental groups. The experimental period was considered as beginning on the 12th day of an estrual cycle and all treatments were timed from this stage. Group I (control) received no injections; groups II, III and IV received progesterone (.4 mg. per lb. of body weight, subcutaneously) from day one through day 17 of the experiment; group IV also received 20 mg. estradiol and group V 20 mg. estradiol only on day 14. Group II was slaughtered on day 25 of the experiment while all others were killed on day 18. Pituitary glands were tested for gonadotrophic potency using 5-day old white leghorn cockerels. Chick testis weights for the five different treatment groups were 54, 56, 70, 69 and 63 mg. ($P \cong .20$) and comb weights were 114, 94, 147, 158 and 113 mg. ($P < .05$).

Considering the ovaries of the gilts: the numbers of 3–7 mm. follicles for each treatment were 19.6, 3.0, 36.0, 9.2 and 3.5 ($P<.01$) and the numbers of follicles freshly ovulated or greater than 7 mm. were 0.3, 13.6, 0.8, 0.0 and 0.2. The differential response of the chick comb to pituitaries from the different experimental groups suggest that progesterone affects the luteinizing factor of the gonadotrophic complex. The relatively greater effect on comb variation than on testis variation, in this experiment, is consistent with there being a greater "damming up" of the luteinizer than of the follicle stimulator. Withdrawing progesterone led to its release but estradiol did not. The latter suppressed development of 3–7 mm. follicles.

THE EFFECT OF VARIATIONS IN AMBIENT TEMPERATURE AND HUMIDITY ON RECTAL AND TESTIS TEMPERATURES OF SHEARED AND UNSHEARED RAMS. W. C. Foote, A. L. Pope, R. E. Nichols and L. E. Casida, *University of Wisconsin.*

The effect of three levels of ambient temperature (70, 82, 95°) and high (78–88%) and low (57–69%) humidity on rectal and intratesticular temperature was studied in five sheared and five unsheared rams of mixed breeding. Highly significant differences in rectal temperatures were shown for the different levels of ambient temperature (70, 102.36; 82, 102.91; 95, 104.50°) and humidity (103.48 high *vs.* 103.03° low) with some indication of an interaction between them ($P\cong0.08$). Rectal temperatures for sheared and unsheared rams were 102.89 and 103.62° ($P\cong0.08$). Testis temperatures of 95.46, 95.36, and 98.76° due to 70, 82 and 95° ambient temperature; 96.04, and 97.02° due to low and high humidity; and 95.65 and 97.40° for sheared and unsheared rams showed differences which were highly significant. Interactions were indicated between shearing and ambient temperature ($P<0.01$), shearing and humidity ($P\cong0.08$), ambient temperatures and humidity ($P<0.01$), and between all three variables ($P\cong0.08$). An increase from 75–95° ambient temperature caused a greater change in testis than rectal temperatures (3.31 *vs.* 2.14°, $P<0.01$). Interactions of the sites of these internal temperatures (testis and rectal) with humidity and shearing showed similar results when taken independently ($P<0.05$, and $P\cong0.09$ respectively). The site of internal temperatures also interacted significantly with these two factors when taken jointly ($P<0.05$).

THE RELATIVE LACTOGENIC HORMONE CONTENT OF THE PITUITARIES OF REPEAT-BREEDER AND FIRST-SERVICE DAIRY CATTLE AT 16 DAYS POST-BREEDING. C. A. Kiddy, W. H. McShan and L. E. Casida, *University of Wisconsin.*

Partial failure of the corpus luteum-maintaining mechanism, with a consequent diminution of progesterone secretion, could theoretically be a cause of early embryonic death in repeat-breeding cattle. With the assumption that lactogenic hormone is responsible for the maintenance of corpora lutea in cattle, comparison was made of the relative lactogenic potency of the pituitaries (collected 16 days post-breeding) of 10 repeat-breeder and 10 first-service dairy cattle as a test for a difference in the "maintaining" mechanisms for the corpora lutea of the two kinds of cattle. The acetone desiccated pituitary powder was tested for its stimulating action on the pigeon crop-gland. Since the response to the intradermal injection is local, it was possible to compare the two types of cattle pituitaries within pigeons to minimize the effect of individual pigeon variation in response.

(Each pigeon received an injection of repeat-breeder pituitary gland on one side and of first-service pituitary gland on the other side of the crop-gland.) Analysis of the weights of stimulated crop-gland areas failed to show any significant difference between the two types of pituitaries; or between individual pituitaries. The only significant difference was the difference in response between pigeons. Pituitary powder boiled at pH 9 to 10 for one hour did not give a response while unboiled portions gave the response in the same pigeon. Acetone desiccated liver, pancreas, and muscle also failed to induce a response. Thus, it is reasonable to assume that the response measured was actually a response to lactogenic hormone.

THE EFFECT OF CARBOXYLIC ACIDS ON GAS PRODUCTION BY RUMEN MICROORGANISMS AND ITS POSSIBLE RELATION TO LEGUME BLOAT. W. G. Rosen, Hester Fassel and R. E. Nichols, *University of Wisconsin.*

Aqueous extracts of alfalfa hay or meal and juice expressed from fresh or frozen alfalfa caused large "gas bursts" when added to bovine rumen liquor in Warburg vessels. The gas produced was all, or almost all, CO_2 of microbial origin. Similarly prepared extracts from non-bloat-provoking feeds such as fresh grass or grass hay caused smaller bursts. The gas-producing activity was non-volatile, heat-stable, dialyzable, and not precipitated by acetone or by acidification. It was retained by anion exchange resins but not by cation exchange resins. The activity, on paper chromatograms, was recoverable from zones which reacted as acids when sprayed with a pH indicator. Manometric studies with known plant metabolites in low concentrations and at physiological pH's revealed that succinic, malic, malonic, and citric acids possessed marked gas-producing activity whereas various other organic acids, amino acids, sugars, etc. had little or no activity. Co-chromatography of alfalfa extracts with known acids revealed that the activity of the former resided largely in zones with Rf's similar to those of malic, malonic, and citric acids. Malonic acid was not detected an chromatograms of the grass extracts. Thus the activity of the extracts appeared to be related to their content of certain organic acids. It is suggested that the bloat-provoking power of alfalfa may result from the relative abundance therein of substrates available for microbial decraboxylations. The consequent release of large amounts of CO_2 (which may be trapped in froth made stable by saponins, colloids, etc.) may be a major factor in the etiology of legume bloat.

THE DISTRIBUTION OF SPERMATOZOA IN THE BOVINE MALE REPRODUCTIVE TRACT. G. Bialy and Vearl R. Smith, *University of Wisconsin.*

There is little or no published information on the distribution of spermatozoa in the reproductive tract of the bull. This study was undertaken to determine the contribution of sperm from different parts of the reproductive tract to the ejaculate. Bull reproductive organs were obtained from dairy bulls slaughtered at the local abattoir. The sections of the reproductive tract studied were the ampullae, vasa deferentia and the epididymes. The organs were sectioned into their various anatomical parts. The epididymes were sectioned into the caput, corpus and cauda. The spermatozoa were flushed from the ampullae and vas deferentia with an isotonic sodium citrate solution. The various sections of the epididymes were macerated in a Waring blendor and diluted with sodium citrate. The spermatozoan numbers for each section of the tract were determined by hemocytometer counts. In the case of the epididymes, spermatozoan heads only were counted, because of the break-up of the spermatozoa as the result of maceration. Twenty-two single

ampullae averaged $417{,}952 \times 10^3$. Counts of 11 single vasa deferentia averaged $313{,}345 \times 10^3$ spermatozoa. Average number of sperm in the cauda epididymie obtained from 25 specimens was $8{,}880{,}632 \times 10^3$. Counts of 18 combined ampulae and vasa deferentia averaged $821{,}955 \times 10^3$ sperm. Paired counts of 10 ampullae and vasa deferentia separately averaged $722{,}000 \times 10^3$, and $340{,}000 \times 10^3$, respectively. Studies now in progress indicate that there may be a seasonal trend in the distribution of spermatozoa in the various parts of the epididymis.

LIVABILITY OF BOVINE SPERMATOZOA IN BICARBONATE AND LACTATE BUFFERS WITH YOLK. E. L. Willett and J. I. Ohms, *American Foundation for the Study of Genetics.*

Three experiments were conducted to compare the livability of bovine spermatozoa in yolk buffered with citrate (YC), lactate (YGL), and bicarbonate (YGB). In each diluter the proportion of yolk and buffer was 1:1. All diluters contained 500 mcg. dihydrostreptomycin sulfate per ml. A 5% solution of glucose comprised 67% of the volume of YGL and YGB. In one experiment YGL at a low (6.46) and normal (6.85) pH. YC and YGB were compared with and without 0.3% sulfanilamide. Sulfa significantly improved livability in YC and YGB after 7 days storage at 5° C., but not in YCL. Addition of $NaHCO_3$ after 7 days storage improved motility in the YGL diluters within 5 min. at 37° C. A second experiment compared motility in YC at low (6.42) and normal (6.78) pH and YGL at low (6.43) pH. After 7 days storage $NaHCO_3$ and NaOH were added to separate vials of the three diluters, and the vials were then allowed to stand for 1 hour at 25° C. and also for 24 hours at 5° C. Both additives increased motility in YGL, and NaOH more than $NaHCO_3$ ($P<0.05$). Motility after the 24-hr. period in YGL with the $NaHCO_3$ additive was higher than after 1 hr. at 25° C. ($P<0.01$) but not in the NaOH additive. A third experiment compared motilities in YGL at low (6.37) and normal (6.92) pH and YC. Addition of NaOH increased motility in both YGL diluters. In all experiments motilities in either the YGL or YGB, with and without additives, were not superior to those in YC. In most cases, motilities in YCL, especially at low pH, were poor, but were markedly improved by the additives.

MINIATURE PIG METABOLISM CAGE FOR RADIOBIOLOGICAL STUDIES. V. G. Horstman, L. A. George, Jr., M. E. Kerr and L. K. Bustad, *Hanford Laboratories Operation, General Electric Co.*

This paper describes an adaptable metabolism cage for handling male miniature pigs administered high level amounts of alpha and beta-emitting isotopes. This cage is constructed of steel frame with lucite sides for easy observation of the confined animal. The eight-inch glove ports on each side are fitted with rubber gloves or plastic bags. The floor of the cage is of stainless steel for easy decontamination. Adjustable floor plates and side baffle plates make it possible to accommodate pigs from 75 to 300 lb. in weight. Completely air-tight, the cage has its own air supply and filtering system. Special construction provides effective separation of urine and feces. The excreta is collected in jars that can be removed in plastic bags and sealed, preventing spread of contamination. The pig can be fed and watered from outside by means of a pipe leading to a trough embedded in the floor of the cage. The pig seems to adapt well to this type of confinement.

Extension Section

R. M. McWILLIAMS, *Chairman*

NOMOGRAPHIC ADJUSTMENT OF THE WEIGHTS OF ILLINOIS SWINE HERD IMPROVEMENT ASSOCIATION LITTERS. H. W. Bean, *University of Illinois.*

The Illinois Swine Herd Improvement Association has sponsored a weight-testing program of weanling pigs for many years. Since the spring of 1952 more than 85,000 pigs were weighed. Their age, when weighed, ranged from 21 to 66 days. Optimum comparisons are made when all pigs are weighed at the same age but this is practically impossible. The weight of each litter is adjusted to an estimated weight at a given age. Linear equations were calculated from the data gathered during the course of the program. To adjust the weight of pigs 21 to 38 days old, the equation $Y=.55X-1.55$ was used. To adjust the weight of pigs 38 to 66 days old, the equation $Y=.74X-8.66$ was used. Theoretical weights were then calculated for each age which served as the basis for the construction of nomographic charts. Nomographs are constructed to adjust the weight of pigs to the following ages: 21, 28, 35, and 56 days.

NEWS AND NOTES

1956 Annual Meeting. The annual meeting of the American Society of Animal Production will be held at the Hotel Sherman, Chicago, Illinois, on November 23 and 24.

The Nominating Committee of the American Society of Animal Production has proposed the following list of candidates to be presented at the annual business meeting: for President, J. C. Miller; for Vice-President, W. M. Beeson; for Secretary-Treasurer, E. R. Barrick and H. H. Stonaker.

L. A. Moore, formerly Head, Nutrition and Physiology Section, has been appointed Assistant Chief, Dairy Husbandry Research Branch, U. S. Department of Agriculture.

J. F. Sykes, formerly Assistant Head, Nutrition and Physiology Section, has been appointed to succeed Dr. Moore as Head.

N. D. Bayley has been appointed Head, Breeding, Feeding and Management Section. Dr. Bayley succeeds M. H. Fohrman who retired from that position.

Harold W. Hawk has been appointed Physiologist in the Nutrition and Physiology Section.

Joel Bitman has been appointed Biochemist in the Nutrition and Physiology Section, U.S.D.A.

C. E. Calverley, formerly Director of Nutrition for Russell-Miller Milling Co., Minneapolis, became manager of the feed and flour products laboratory of Lindsey-Robinson and Co., Inc., Roanoke, Va., July 1.

David C. Church, 1956 Ph.D. from Oklahoma A. & M. has accepted an instructorship in the Animal Husbandry Department in nutrition at Oregon State College.

James A. B. McArthur, of the Dominion Experiment Station, Manyberries, Alberta, became Superintendent of the Eastern Oregon Livestock Experiment Station, Union, Oregon, in September.

W. Dean Frischknecht became Animal Husbandry Extension Specialist at Oregon State, July 1.

W. W. Ellis, Oregon State College Ph.D. in Animal Nutrition and Instructor in Animal Husbandry has joined the staff of research chemistry at the University of Wyoming.

George Nelms, formerly of Oregon State College, has become Assistant Professor of Animal Husbandry at the University of Arizona.

Alan Anglemier, 1956 Ph.D., Oregon State College in animal nutrition has accepted an appointment with the Department of Food Technology to do Research work on the factors affecting the palatability of beef.

Fred F. McKenzie, Head, Department of Animal Husbandry, Oregon State College has been granted a two-year leave of absence to join the staff of the University of Nebraska on their I.C.A. contract with the University of Ankara, Turkey, where he will do research, teaching and extension work in artificial insemination. John H. Landers, Jr., will become acting Head of the Department.

Jorge de Alba, Head of the Department of Animal Husbandry, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica, is on leave on a Guggenheim fellowship at Cornell University, where he is preparing texts, in Spanish, on Animal Feeding and Animal Breeding with special emphasis on tropical problems. Candelario Carrera is acting Head of the Department at Turrialba.

John V. Bateman, formerly of the Department of Dairy Industry, Oregon State College, has joined the Inter-American Institute of Agricultural Science, Turrialba, Costa Rica, as Nutritionist for the Department of Animal Industry.

Section O. of the AAAS has arranged a rather comprehensive program on the theme: "Grasslands in our National Life" for the New York Meeting December 26–31, 1956. This program has 3 major parts: (1) Symposium of invitation speakers, on December 29–30; (2) Companion programs on grasslands by several individual societies; (3) Volunteer papers by any qualified person on: *Grassland Reports—Research and Practice,* December 27 and 28.

The 17th Annual Meeting of the Western Section of the American Society of Animal Production was held jointly with the Annual Meeting of the Western Division of the American Dairy Science Association on the campus of the University of Nevada, Reno, July 15–18, 1956. Two hundred and three people registered for the joint meetings, at which a total of 93 scientific papers was presented. Registrants came from the eleven Western States, Texas, Maryland, Wisconsin, Minnesota, Illinois, Kentucky, Oklahoma, Iowa, Missouri, Canada and Hawaii. Feature addresses were given by J. L. Lush, Iowa; Max Kleiber, California; Samuel Brody, Missouri; John L. Fischer, Nevada; B. S. Schweigert, American Meat Institute; and N. R. Ellis, U.S.D.A. The Technical Committee of Western Regional Project WM–23 on Wool Marketing and the Technical Committee on Western Regional Project W–34 on Range Livestock Nutrition met on July 13 and 14. The Subcommittee on Sheep Nutrition, National Research Council, met on July 15. The Western Livestock Extension Specialists met on July 15 and presented a special program on July 17.

The AAAS has recently published a volume entitled "The Future of Arid Lands", containing the proceedings of a conference last year in New Mexico. Papers by some 34 authors deal with the following subjects: Variability and predictability of water supply; Better use of present resources; Prospects for additional water sources; Better adaptation of plants and animals to arid conditions.

A publication entitled "Recent Developments Affecting Livestock Production in the Americas" has been issued by the Food and Agriculture Organization of the United Nations in Rome, Italy, as FAO Agricultural Development Paper No. 55, edited by Ralph W. Phillips. Particular attention is given to animal climatology, herdbooks and performance tests, artificial insemination and storage of semen, national planning and management aspects of the grazing industry, technical problems in the use of grasslands, conservation of forage, foot-and-mouth disease, brucellosis, parasite control and control of diseases transmitted by parasites, the poultry industry, interpretation and evaluation of results of animal husbandry and veterinary experiments, and national services to the livestock industry. The publication may be obtained at $1.50, in the U.S.A. from the Columbia University Press, International Documents Service, 2960 Broadway, New York 27, N. Y. It is available in Spanish, under the title "Ultimas Novedades de la Industria Pecuaria en las Americas".

A new book, "Applied Animal Nutrition", by E. W. Crampton was published recently by W. H. Freeman and Co., San Francisco, California. The book is

divided into five sections: 1. What are Feedstuffs; 2. Nutritional Requirements of Animals; 3. The Nutritional Characteristics of Some Common Feeds; 4. Ration Formulation; 5. Appendices, Miscellaneous Feeding Guides, Feedstuffs Control and Legislation, Table of Feed Composition and Conversion Charts. The new approach to the subject and the emphasis on the formulation of mixed feeds makes the book an important contribution to livestock feeding and nutrition. Jorge de Alba.

The 22nd edition of "Feeds and Feeding" by F. B. Morrison was published in October, 1956. The page is changed to a two column format and many new cuts have been used. The book has been completely revised and brought up to date. It remains the comprehensive volume with which students and stockmen are familiar.

John F. Wise, formerly Assistant County Agent, Laurens, South Carolina, is now Extension Livestock Specialist—Marketing, at The Clemson Agricultural College, Clemson, South Carolina.

Richard F. Wheeler, formerly Associate Professor of Animal Husbandry, was appointed Head, of the Animal Husbandry Department at Clemson.

Haley M. Jamison, formerly Assistant County Agent in Virginia, has been appointed Extension Sheep Specialist at the Clemson Agricultural College.

The Southern Section of the American Society of Animal Production will have its annual meeting on February 4–6, 1957, at Birmingham, Alabama, with the Animal Husbandry headquarters being in the Redmond Hotel. Officers of the Southern Section are: W. P. Garrigus, President, B. L. Southwell, Vice-President and C. S. Hobbs, Secretary-Treasurer.

Emmit H. Haynes has been appointed Assistant Professor in Extension Animal Husbandry, Iowa State College. Mr. Haynes is a native of Kentucky and received his B.S. and M.S. degrees from the University of Kentucky. During the past two years he has been doing graduate work in Nutrition at Cornell. He was formerly employed as Agricultural Relations Director for a meat packing concern at Louisville. His work will consist of nutrition and the direction of the sheep extension activities.

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